

People and the Sound

MARINE TRANSPORTATION

A Planning Report prepared for the New England River
Basins Commission by the U.S. Department of the Army,
Corps of Engineers



The Long Island Sound Regional Study is a "level B water and related land resources study." It was conducted under provisions of the federal Water Resources Planning Act of 1965. The Plan which has been developed was prepared by a team of federal, state, and regional officials, local citizens, and the scientific community, under the overall coordination of the New England River Basins Commission. It is a part of the Commission's comprehensive, coordinated joint plan for the water and related land resources of its region, which includes New England and the New York portions of Long Island Sound.

The plan for Long Island Sound recommends a program for action by federal, state, and local governments; it does not bind them to undertake specific recommended actions. To assist in the evaluation and implementation process, the following reports have been prepared:

A PLAN FOR LONG ISLAND SOUND: A SUMMARY. Highlights of the plan and a brief discussion of the rationale leading to recommendations.

A PLAN FOR LONG ISLAND SOUND: SUPPLEMENT. A more comprehensive planning document which enumerates the major alternatives considered in formulating the recommendations, together with an explanation of how the plan was prepared, who did the work, and background information organized both by subject matter and by geographical sub-regions of the Study Area.

PLANNING REPORTS. Each planning report was developed by a "Work Group," chaired by a federal agency, with the active participation of state and local agencies, other federal agencies and citizen and scientific advisors. These reports incorporate data (originally published in a series of Interim Reports) which estimate people's demands for the resources of the Sound region, the requirements needed to meet those demands, the existing capacity of the region to meet the requirements, and any deficiencies noted.

The second half of each planning report develops solutions by stating objectives in terms of satisfying defined needs, suggesting alternative ways to achieve the objective, evaluating each alternative in terms of environmental, economic, and social criteria, developing economic, environmental, and composite plans, and finally making recommendations.

The following Planning Reports were prepared

Water Management by the U. S. Environmental Protection Agency, and the States of New York and Connecticut.

Land Use by Ralph M. Field and Associates for the U. S. Department of Housing and Urban Development.

Outdoor Recreation by the U. S. Department of the Interior, Bureau of Outdoor Recreation.

Fish and Wildlife by the U. S. Department of the Interior, Fish and Wildlife Service; and the U. S. Department of Commerce, National Marine Fisheries Service.

Shoreline Appearance and Design by the U. S. Department of the Interior, National Park Service and Roy Mann and Associates.

Marine Transportation by the U. S. Department of the Army, Corps of Engineers.

Power and the Environment by Federal Power Commission staff

Mineral Resources and Mining by the U. S. Department of the Interior, Bureau of Mines.

Flood Damage Reduction by the U. S. Department of the Army, Corps of Engineers; and the U. S. Department of Agriculture, Soil Conservation Service.

Erosion and Sedimentation by the U. S. Department of the Army, Corps of Engineers; and the U. S. Department of Agriculture, Soil Conservation Service.

OTHER REPORTS published in conjunction with the Study are:

An Economic Perspective by the U. S. Department of Agriculture, Economic Research Service; and the U. S. Department of Commerce, Bureau of Economic Analysis. An examination of the economic and demographic trends in the region, with data for use as the basis of all projections made in the Study

Shoreline Appearance and Design: A Planning Handbook by Roy Mann Associates, Inc., for the U. S. Department of the Interior, National Park Service. Recommended management procedures for protecting and enhancing the region's scenic resources.

Sources and Movement of Water by the U. S. Geological Survey, Water Resources Division; and the National Oceanic and Atmospheric Administration. A summary of the hydrology and climate of the region.

Soils by the U. S. Department of Agriculture, Soil Conservation Service. An inventory and analysis of soil composition in the region.

For a complete listing of reports published by or in conjunction with the Study, see Appendix A of the Supplement. Copies of these reports are available from:

New England River Basins Commission
55 Court Street
Boston, Mass. 02108

National Technical Information Service
Springfield, Va. 22151

MARINE TRANSPORTATION

PLANNING REPORT

Long Island Sound Regional Study
New England River Basins Commission
270 Orange Street
New Haven, Connecticut 06511

A Report Prepared by
Corps of Engineers
U. S. Department of the Army

with contributions from

U. S. Department of Transportation
U. S. Department of Commerce
Maritime Administration

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FOREWORD

Long Island Sound is one of the nation's unique and irreplaceable natural resources. An almost fully enclosed arm of the ocean, it has over 1300 square miles of water surface and over 600 miles of coastline. Spreading eastward along both shores from the great metropolitan center which lies at the Sound's western end, a growing concentration of increasingly affluent people make ever greater demands on this urban sea. At the same time, there is a growing feeling that the conflicting demands are destroying the Sound, and that the problems must be resolved if the Sound is to be preserved.

The Long Island Sound Regional Study is a comprehensive planning effort by the Federal government and New York and Connecticut, led by the New England River Basins Commission. Assisting the Commission are professionals from many disciplines representing the Federal, state and regional agencies listed on the back cover, a Citizen Advisory Committee, and a Research/Planning Advisory Committee composed of members of the region's scientific community.

THE GOAL OF THE STUDY IS TO PRODUCE A PLAN OF ACTION BY THE SPRING OF 1975 WHICH BALANCES THE NEEDS TO PROTECT, CONSERVE AND WISELY DEVELOP THE SOUND AND ITS RELATED SHORELANDS AS A MAJOR ECONOMIC AND LIFE-ENRICHING RESOURCE FOR THE 12 MILLION PEOPLE WHO LIVE NEAR IT.

This planning report is one of a series. The first half of each report is problem-oriented. It summarizes demands placed upon the Sound and adjacent lands, their capacity to supply these demands, and present or expected needs to be met, if it is determined that supply should meet demand. The last half of each report is solution-oriented. It formulates tentative objectives and alternative measures for achieving the objectives. It evaluates the environmental, economic and social implications of each measure and formulates alternative plans. One plan is tentatively recommended. The planning reports are printed and distributed before the final version of main report. Therefore, final recommendations are to be found only in the main report, scheduled for publication in the Spring of 1975. Planning reports in this series include:

Land Use
Water Management
Shoreline Appearance & Design
Erosion and Sedimentation
Flood Damage Reduction

Recreation
Fish and Wildlife
Marine Transportation
Minerals
Power and the Environment

SUMMARY

THE PURPOSE OF THIS REPORT. The purpose of this report is to assemble information on the present transportation system in the Long Island Sound Study region, with special emphasis on waterborne commerce, and to recommend an economically, environmentally and socially acceptable plan to meet future demands.

HOW IMPORTANT IS TRANSPORTATION TO THE PUBLIC?

Virtually everyone living in Connecticut and Long Island depends upon Long Island Sound for the petroleum that generates their electricity, fuels their cars and trucks, and heats their homes and businesses. Since oil will remain the chief energy source for some years to come, it is anticipated that oil receipts at Long Island Sound ports will more than double by the year 1990--reaching a level of about 320 million barrels a year.

The ports also handle large quantities of construction materials (sand, gravel and crushed stone) and other bulk cargo, including scrap metal, lumber, and chemicals. Although these shipments will not increase as dramatically as oil, they will still constitute a significant part of the water and port traffic in the years to come.

The goods and people brought into LIS ports depend upon land transportation--primarily highway--for distribution. As the population and the goods received increase, already congested highways will grow more congested unless steps are taken to alter present distribution systems.

HOW DOES THE SOUND MEET PRESENT TRANSPORTATION DEMANDS?

The total LIS transportation system consists of marine, highway, pipeline, rail and air transport.

In 1971, the present waterborne transportation system moved 40 million tons of cargo into 18 ports in Connecticut and Long Island, but there are major problems in regard to navigation and harbor facilities. Shallow channels require dredging, which is potentially dangerous to the environment; but the present use of large numbers of small coastal vessels and barges and the lightering of tankers is the possible source of even greater environmental damage--oil spillage.

The large number of small harbors is both inefficient and environmentally unsound. Conflicts arise between industrial and residential or recreational waterfront development and between commercial and recreational vessels. Waterfront storage of oil products, the usual practice, adds to the possibility of oil spills and causes many ports to be eyesores.

Waterfront storage also plays a large role in highway traffic congestion since distribution out of LIS ports is primarily by truck. Truck traffic adds to highways already clogged with commuter and recreational automobile traffic. An alternative to truck traffic could be extensive improvement in rail freight transport but little is being done in this direction at present.

OBJECTIVE AND ALTERNATIVE MEASURES.

This study chose five objectives for the Sound's transportation systems: minimize the number of trips by oil tankers and barges into and out of the rivers and harbors; reduce the amount of shorefront land used for oil handling facilities; alleviate the congestion of the highway distribution system; find environmentally and economically acceptable methods of dredge spoil disposal; and facilitate movement of people and dry cargo. The alternative measures fell into four categories: receiving system, handling systems, distribution systems, and people movements.

EVALUATION

All of the alternative measures were evaluated in terms of 45 environmental, economic and social criteria, both generally and with respect to each port in each market area.

WORK GROUP RECOMMENDATIONS

Considering the receiving, handling and distribution systems simultaneously, the study recommended that the following major elements be included in the final plan:

1. Consolidation of ports into a few key receiving ports, either by deepening present channels or by constructing off-shore berths.
2. Pipelines to distribute fuel to major consumption centers.
3. Inland tank farms.
4. Year-round ferry service for movement of people and cargo.

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1.0 THE PURPOSE OF THIS REPORT

The purpose of this report is to assemble information on the present transportation system in the Long Island Sound Study region with special emphasis on waterborne commerce, and to recommend an economically, environmentally and socially acceptable plan to meet future demand.

2.0 TRANSPORTATION AND THE PUBLIC

2.1 Historic and Future Transportation Patterns

The Connecticut shore was originally settled around harbor cities but the railroad later stimulated their growth and fusion into an industrial corridor along the western half of the shore. On Long Island, the three branches of the railroad served a different development function -- to extend the New York commuter and vacation shed to the end of the Island. To this basic pattern, the automobile and truck, on the arteries built to serve them, contributed to a scattering of residences, shopping centers, and industry, with heavy impact on the shore areas of the western half of the Sound.

Transportation facilities both affect and are affected by housing patterns and job opportunities. Scattering residences makes the use of public transportation much more difficult. This in turn contributes to dependence on the private automobile for transportation, accompanied by severe air pollution problems. Lack of a viable rail freight system forces industrial, commercial and business interests to turn to trucking in order to move goods, similarly increasing the amount of contaminants in the air. At the same time, without good commercial transportation available, the ability to attract new and desirable industries into the region is lessened, reducing employment opportunities for the residents as well. However, the converse is also true: increased dependence on public transportation both for freight and commuting can stimulate improved and expanded service for the LIS region.

The type of transportation facilities planned for the future will vitally affect the development of the LIS region. Connecting routes, siting of residences and businesses, and governmental transportation policies will determine to a great extent the life styles of individuals. In addition to the changes possible from extensive use of mass transit and rail freight service, new transportation developments on the water can stimulate different types of development on shore. Off-shore petroleum receiving berths or near-shore products-islands could basically alter the use of waterfront land.

Shoreside storage tanks could be moved to inland distribution centers connected by pipeline to the islands or off-shore terminals. Prime waterfront land, formerly used for docking and storage purposes could be freed for redevelopment for commercial, recreational and/or conservation purposes. Careful planning now for these concerns is essential to insure adequacy of transportation facilities, as well as properly controlled demand, growth and variety of services to meet the needs -- and desires -- of the public.

2.2 Public Reliance on Marine Transportation

The people living on Long Island and in eastern New York State, Connecticut, southern Vermont and western Massachusetts depend on Long Island Sound to move the necessary goods supplying the entire region. Most of the waterborne commerce transports petroleum products used in electrical generating plants, industries, heating and land transportation. Building and construction materials, some chemicals and scrap metals make up the rest of the products shipped on the Sound.

Although research and development is under way to develop new types of automobile engines and new fuels for both vehicles and power plants, there is little likelihood that such designs and power sources will be in extensive use before 1985, if by then. Thus, petroleum will continue to be the major product shipped on LIS and in use in the region for some time to come.

2.3 Land Transportation Out of the Ports

Both people and the goods brought into the LIS harbors require adequate ground transportation out of the ports. Waterborne commerce, formerly almost totally linked to rail transfer, has shifted land-based operations to trucks and pipelines.

Petroleum, supplying more than 75 percent of all energy consumed in the market area, is brought in primarily by small tankers and barges, with very little shipped from outside LIS region overland by truck or rail tank cars.

Most of the petroleum products destined for the LIS region originate in the Gulf Coast area, the Caribbean, Africa or the Middle East, although some petroleum products are refined in New Jersey and then transshipped to the area. Once in port, the petroleum is stored in shorefront tanks and distributed within the region by truck, pipeline or barge where needed.

Construction materials, primarily sand, gravel and crushed stone, constitute the second largest group of commodities by tonnage on LIS. Sand is mined on the north shore of Long Island and shipped to

New York and western Connecticut ports. Stone and crushed rock are mined in Connecticut and along the Hudson River and shipped by barge to ports throughout the Sound. Trucks take the products to their appropriate destination, primarily because individual producers or users generally need less than truckload lots and several deliveries can be consolidated into a single truckload. Most of the materials are stored on the waterfront until needed for distribution. Although it is possible to move sand, gravel and crushed stone by conveyor belt out of the harbor or by a pipeline slurry, these methods are not in use at the present time in the LIS region.

Rail service to and from port facilities is almost nonexistent now, neglected in many cases because of scheduling problems or the availability of equipment. Containerized cargo handling from sea to rail or truck facilities may become more important in the future if the market and handling facilities warrant. However, land transportation of all goods is highly competitive with alternate water transportation systems such as barges, or with pipelines.

Automobiles and rail primarily handle movements of people in the LIS region, both from the limited ferry service into ports and within the LIS region as a whole. Regular commuters to New York City or other urban areas use their cars alone or in combination with rail service for the daily trip. Bus service, where available, is largely for short trips, although the auto-park-and-ride-by-bus system could become important in the future. The automobile must be used for trips to most recreation areas and to airports, because generally there is no public transportation to these facilities.

Movement of both people and goods on land greatly depends on highways. Increases in both population and the goods needed will increase the already congested highway networks in the LIS region, unless steps are taken to improve or alter present distribution patterns.

2.4 Demand Projections for Land and Water Transport

Energy consumption in the LIS area shows a long-continued and impressive rate of growth and it is rather difficult to visualize a major change in this trend without a major change in the nature and goals of the American people as a nation.

Currently, petroleum and natural gas share leadership in the energy market. In the Long Island Sound region, consumption of electricity grows at a slower rate than that of the country as a whole, but it still more than triples every twenty years. In 1970, 40 percent (or over 200,000 barrels per day) of total petroleum products shipped on the Sound were used for

electric power generation. Nuclear power currently provides only 8 percent of the LIS region's electric power. Nuclear power's ability to gain a larger share of the energy market will remain constrained until problems in establishing standards for radioactive emissions and in overcoming public opposition to locating such plants in or near population centers are resolved. Individual fossil fuels will hold their relative position until nuclear power or another form of energy is developed to a competitive degree.

Table 1 summarizes demand for major petroleum products from Long Island Sound ports in recent years and projects future demand. Notice the close past correlation between the growth of port deliveries

and the growth of total personal income in the market areas served by the ports. The correlation has been used to project future demand on the ports. The closeness of the correlation is not surprising. Total personal income is a product of population and affluence (per capita income) and these are the two major factors that trigger the three principal uses of petroleum products -- electric power production (residuals, space heating (distillates) and transportation (gasoline).

In using personal income as the basis for these projections, the reader should be aware that they produce a considerable leveling off of the rate of increase in future demand of distillate and gasoline products. From 1958 to 1970 total personal increased by an annual compounded rate of 7.0 percent on Long Island and 5.2 percent on the mainland. The total income projections used in this study show a leveling off to 4.4 percent from 1970 to 1990 and to only 3.3 percent from 1990 to 2020. Without this damping of projected growth in income, the product demand projected in Table 1 would be much greater. For example, if petroleum deliveries to the Long Island Sound ports continue to increase at the 7.0 percent annual compound rate experienced since 1958, the 2020 projection would be about 1,060 million barrels, very much higher than the 210 million barrels projected in Table 1.

The 1970 populations of the Connecticut and New York market areas within this report are rather similar (3.0 million and 3.5 million respectively). Yet the Mainland side ports deliver three times more petroleum products than the Long Island side ports. The disparity is explained by the fact that Connecticut is almost totally dependent upon its ports, whereas Long Island is also served by a major pipeline to Kennedy Airport, by major (undisclosed) deliveries to privately owned loading facilities off Northville and Northport, and by some deliveries to minor ports on the Island's south shore.

TABLE 1 PROJECTED ANNUAL DEMAND FOR MAJOR PETROLEUM
PRODUCTS RECEIVED AT LONG ISLAND SOUND PORTS

YEAR	MAINLAND SIDE					LONG ISLAND SIDE				
	Total ¹		Total ²			Demand (million bbls /yr)		Demand (million bbls /yr)		
	Income (\$ billion)	Resid	Income (\$ billion)	Total	Gas	Dist	Gas	Income (\$ billion)	Resid	Total
1958	6.1	15	6.3	69	24	30		6.3	1	16
1960	6.5	14	9.0	68	25	29		9.0	2	17
1965	8.8	21	11.6	79	26	32		11.6	3	21
1970	11.2	42	14.7	115	36	37		14.7	18	50
1990	27.0	76	34.8	222	79	67		34.8	32	100
2020	67.6	88	93.8	410	190	140		93.8	33	210

1. Total personal income in Connecticut is for the entire State, which corresponds closely with the market area for Connecticut ports.

2. Total personal income in New York is for the Counties of Westchester, Nassau, and Suffolk, which correspond closely with the market area for the New York ports on Long Island Sound.

3. Projected total income was computed for this study by the OBERS, Department of Commerce. Future demand for distillate and gasoline is hereby projected in proportion to the rise in total personal income, a trend which has been followed very closely in recent years. Note that this is a projection of past trends. Even though the energy requirements of the region are expected to grow at an average rate of over 5 percent to the year 2000 and more and more residual fuel will be needed to help meet this demand, it is expected that after 1990 the energy requirement will be primarily met by nuclear power. Forecast of future residual fuel requirements is based largely on future LIS area fossil fuel electric power generating activity as estimated by Federal Power Commission and on industry's need for heating manufacturing and commercial plants throughout the region.

The second most important commodity group, in terms of tonnage shipped on the Sound, is sand, gravel and crushed stone. The following table represents a summary of the projected sand, gravel and crushed stone demand of the region, based on projections made by the Bureau of Mines in the "Interim Report on minerals and mining Resources of the Long Island Region" and the tonnage received and shipped by Long Island Sound ports from the Corps of Engineers statistics modified with an estimation of the New Haven Trap-Rock shipments out of Pine Orchard.

TABLE 2

LONG ISLAND SOUND REGION SAND, GRAVEL AND CRUSHED STONE
DEMAND PROJECTIONS

	<u>1970</u>	<u>1980</u>	<u>1985</u>	<u>2000</u>
	(millions of tons)			
Total Demand	14.3	18.2	21.6	24.4
Waterborne Receipts	3.6	4.5	5.2	7.0
% of Total Demand	25.0	25.0	25.0	29.0
Waterborne Shipments	3.8	4.2	3.7	6.4
Total Waterborne Shipments and Receipts	7.4	8.7	8.9	13.4

Currently, the waterborne receipts account for approximately 25 percent of the total demand for these commodities in the region, but the future of this commerce depends upon the availability of supply. The mines along the shores of the Sound are being depleted and restrictive zoning and other developments are pre-empting other Sound area sources. Still, as can be seen in this table, the public's demand for the products is expected to nearly double by the year 2000. Thus water transportation will continue to play a meaningful role in their distribution, with tonnage averaging above half of total production. Trucks will continue to carry these products on short hauls. Rail link between port and product destination are rare and cost per ton mile is very high. Therefore, the percent of crude material moved by rail historically has been very low. It appears very unlikely that rail movement of sand, gravel and stone will increase to any significant degree by 2020.

In addition to petroleum and construction materials, other commodities though in lesser tonnage, are constantly shipped on LIS. Such commodities as kerosene, jet fuel, chemicals, iron products, asphalt, and cement are in steady use in the area. In 1971, they totaled about 4 million tons and represented 10 percent of the total tonnage handled at Long Island Sound ports. Since 1961, these commodities have been showing an annual growth rate of about 2 percent. If this rate continues, by 2020 the flow of these products into and out of Long Island Sound ports will total about 10 million tons.

On the part of the LIS region's utilities, the medium-term commitment is to residual oil while in the long-term it will be in nuclear power. Waterborne coal traffic is, as a result of the 1973-1974 energy crisis, also expected to increase. The Federal Supply and Environmental Coordination Act of 1974, if passed, will permit the Federal Energy Administrator to select those power plants located in the areas where the burning of non-conforming fuels will not cause undue environmental damage. Even when of equal sulfur content, coal burns dirtier than oil. FEA is expected to order the conversion of these selected plants from the present low sulfur residual oil to the burning of coal. Three power plants presently supplied by LIS water transport have been selected as conversion candidates. They are Middletown, Montville and Port Jefferson. Each are expected sometime in the next year to convert part of their capacity to the burning of coal resulting in a slight reduction of waterborne residual fuel requirements. However, the utilities have encountered some real problems in procuring, burning, transporting and handling of coal. With all of these problems, it is obvious that any large scale coal conversion cannot take place without consistent governmental programs balancing energy availability, fuel economics and environmental considerations. On this basis, coal, if used, is not expected to have any significant effect on this report's water transport plan and recommended actions.

In regard to future demands placed on land-based transportation, the Connecticut and New York Departments of Transportation have made extensive studies of the needs of their respective States. Regional planning agencies such as the Tri-State Regional Planning Commission and the Nassau-Suffolk Regional Planning Board have coordinated their efforts to develop a plan suitable for their regional needs.

A major unknown quantity that will affect both water and land transportation projections in the area is the amount of foreign oil received. In 1971, about 42 million barrels of the total oil received in LIS ports were of foreign origin. At least through this decade, there will be continuing intermittent shortages. The severity of these shortages could affect the development of LIS ports; likewise, the ports must be made as efficient as possible to minimize the affects of such shortages.

2.5 Do Nothing

What is likely to happen if nothing is done? One could not imagine concerned people ignoring a major product transportation lifeline which would accommodate efficiently the ocean fleets of today and tomorrow without adversely affecting the highly sensitive coastal zone and estuarine environment. Ship cargo operations in and through LIS ports, as well as other major ports, have entered a revolution. Dramatic trends in vessel size and their implications with respect to transportation savings and harbor, channel, and port facility improvements cannot be ignored or overlooked without weakening significantly the economic stability of the entire region.

Atlantic Coast outlays for primary port development and maintenance from 1946 to 1965 surpassed the \$1.5 billion level, of which the Federal government spent for general navigation improvements \$560 million and non-Federal interests spent about \$952 million for general cargo facilities and specialized facilities. Clearly, doing nothing to foster this long standing partnership policy for harbor and port development that certainly exists today at LIS ports, would drastically alter commodity movement patterns.

Refined oil products destined for LIS market areas would require re-routing to other coastal ports at a significantly higher cost to the consumer, with no guaranty that these other ports have the capability to receive, handle, and distribute the increased commodity load. As a matter of fact, they could not.

Development constraints placed by people and things must be overcome, not overlooked, to the betterment of all. The tremendous one-trip volume of commodity deliveries associated with larger vessels will require expansion of certain onshore support facilities and the provision of new inland fuel centers. Also, the inland distribution or feeder transportation network may require major modification to insure properly timed receipt or prompt dispatch of huge commodity loads. Furthermore, safety programs and measures regarding ship and equipment design standards, navigation operating procedures, and oil pollution regulations are important companions to provision of adequate navigation and terminal facilities.

Imagine the adverse impacts on the people and their environment in the LIS region if these very essential marine facilities and related activities were let decay as a result of a do nothing plan. Consider the over 320 million barrels of refined oil products expected to be received at LIS ports by 1990. If harbor and channel, or innovative offshore facilities of adequate depth are not provided; if existing land distribution and terminal facilities are not capable of prompt servicing of vessels; and if the coastal estuaries

productive as choice farmlands, are left unprotected - the dangers of potential economic disaster exist in such an atmosphere. Furthermore, the transportation savings made possible through large volume delivery will not materialize to the benefit of the region. Failure to take advantage of the new technology would affect production costs and work to the detriment of the over-all U. S. competitive position. At the same time, LIS coastal harbors' important role in the Sound's system of defense would be sacrificed.

Obviously, sound marine transportation planning has never been more critical. It is not good enough when public and private investors pour \$40 million into a large highspeed U. S. product carrier only to watch its capability be shackled because of inadequate receiving, handling and/or distribution systems.

3.0 TRANSPORTATION - PRESENT CONDITIONS.

3.1 Waterborne Commerce

Long Island Sound is a major lifeline for Long Island, eastern New York and large portions of the State of Connecticut (See Figure 1), and its importance is expected to increase in the future. Although there is some transport of people by ferry, the Sound's vital status is due primarily to importation of energy fuels and, to a lesser degree, to shipment and receipt of construction materials. As the importation of petroleum increases, the level of the Sound's waterborne commerce must rise to meet the demand.

This steadily growing commerce is only one facet of the problem facing LIS ports. While its channel depths are inadequate due to silt accumulation and require dredging, there is deep environmental concern about the effects of such dredging and of spoil disposal. In addition, there is the more general objection by environmentalists to development of petroleum receiving and handling facilities and construction of pipeline distribution systems.

Pressed by the sometimes conflicting pressures of development and conservation, LIS still must handle on a daily basis the commerce discussed below.

The ten principal ports on Long Island Sound, together with secondary harbors and rivers, moved 40 million tons of cargo in 1971. This total includes 26 million tons at Mainland Connecticut and New York ports and 14 million tons at Long Island ports. Table 3 shows the commodities moved and the percentage of total tonnage. (Source McMullen Associates.)

TABLE 3 - 1971 LONG ISLAND SOUND WATERBORNE COMMERCE

<u>Commodity</u>	<u>Connecticut Ports</u>		<u>Long Island Ports</u>	
	<u>Tons</u> (Millions)	<u>%</u>	<u>Tons</u> (Millions)	<u>%</u>
Residual Oil	10.9	42.3	1.8	12.5
Distillate	6.5	25.7	3.5	25.0
Gasoline	4.3	18.5	3.2	23.0
Jet Fuel/ Kerosene	.9	.4	--	--
Other - primarily sand, gravel and stone; (construction materials, chemicals, scrap, etc.)	<u>3.4</u>	<u>13.1</u>	<u>5.5</u>	<u>39.5</u>
Total	26.0	100	14.0	100

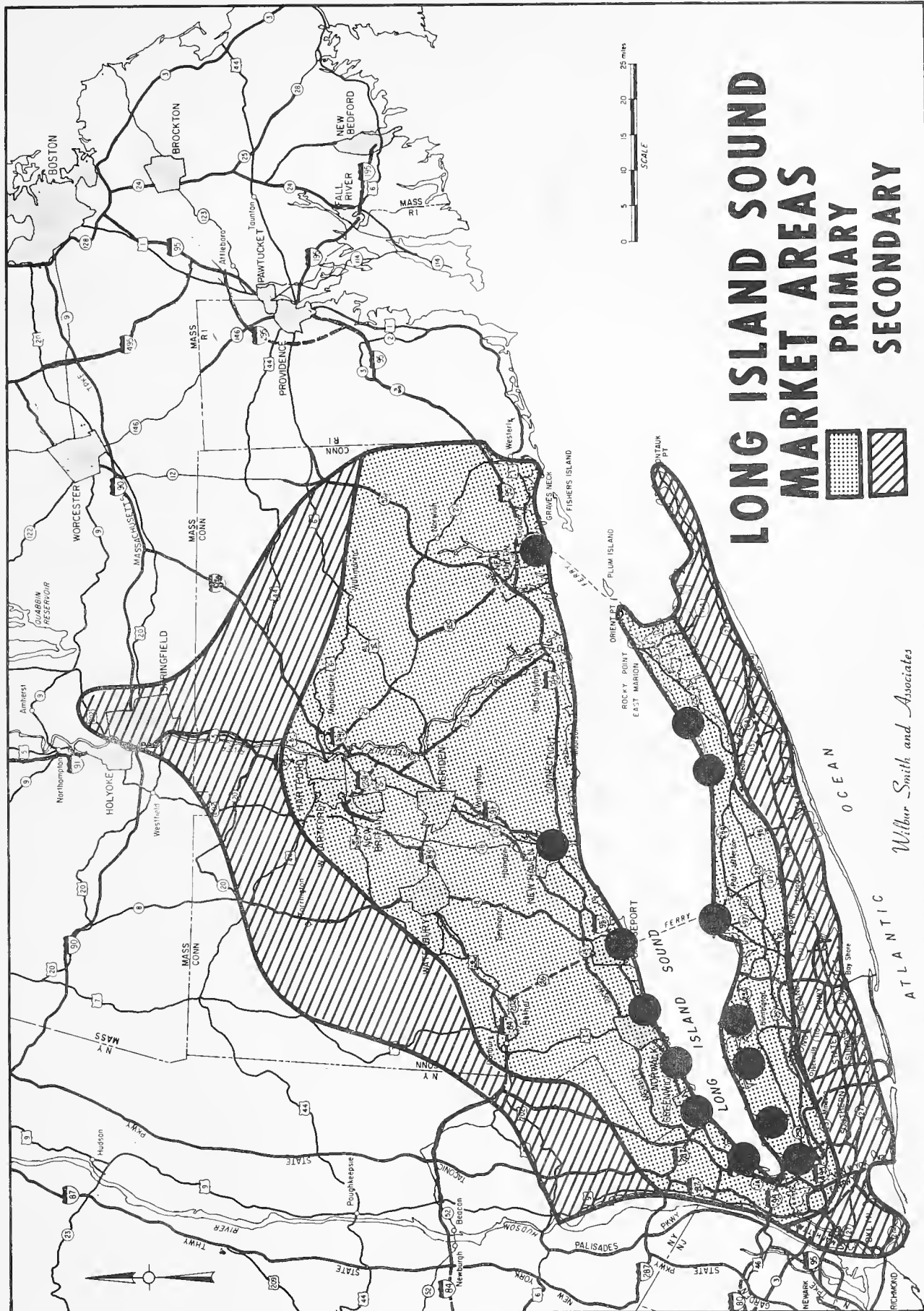


FIGURE 1

As Table 3 indicates, the three major commodities moved in order of volume were: petroleum products (residual, distillate and gasoline); sand and gravel; and other construction materials.

Comparing the 1971 figures with 1962, petroleum transport grew at the annual rate of 6.3 per cent; transport of foreign oil alone jumped at the annual rate of 11.4 per cent. The only commodity group which did not increase in volume during the decade was sand and gravel, whose tonnage remained about the same.

All types of commercial vessels are used in the waterborne transportation system, including barges, general cargo vessels, small coastal vessels, passenger and auto ferries, and petroleum tankers. The tankers pose navigational and environmental problems because of their size. Many of the Sound's harbors have channel depths of 35 feet or less, requiring the tankers to discharge part of their load into barges before they can enter port. This practice not only increases the possibility of oil spillage, it also defeats the economics of large volume carriage and makes many ports unsuitable as major oil ports. For this reason, consideration is presently being given to off-shore facilities, where large tankers can berth and discharge their oil into storage tanks connected to shore by pipelines.

In order to keep pace with the ever-increasing commerce on LIS, local governments or members of the private sector are currently considering or have proposed improvement and expansion plans for many of the Sound's ports. (See Figure 2 for existing ports). These plans are described only briefly here; they are discussed more fully in the Evaluation Section of this report (Section 7).

Mainland Ports. The principal mainland ports are: New London including the Thames River, New Haven, Bridgeport, Connecticut River to Hartford, Stamford, and Eastchester. Pertinent commerce and navigational information concerning these six most active mainland ports, in terms of tonnage handled, is shown in Table 4.

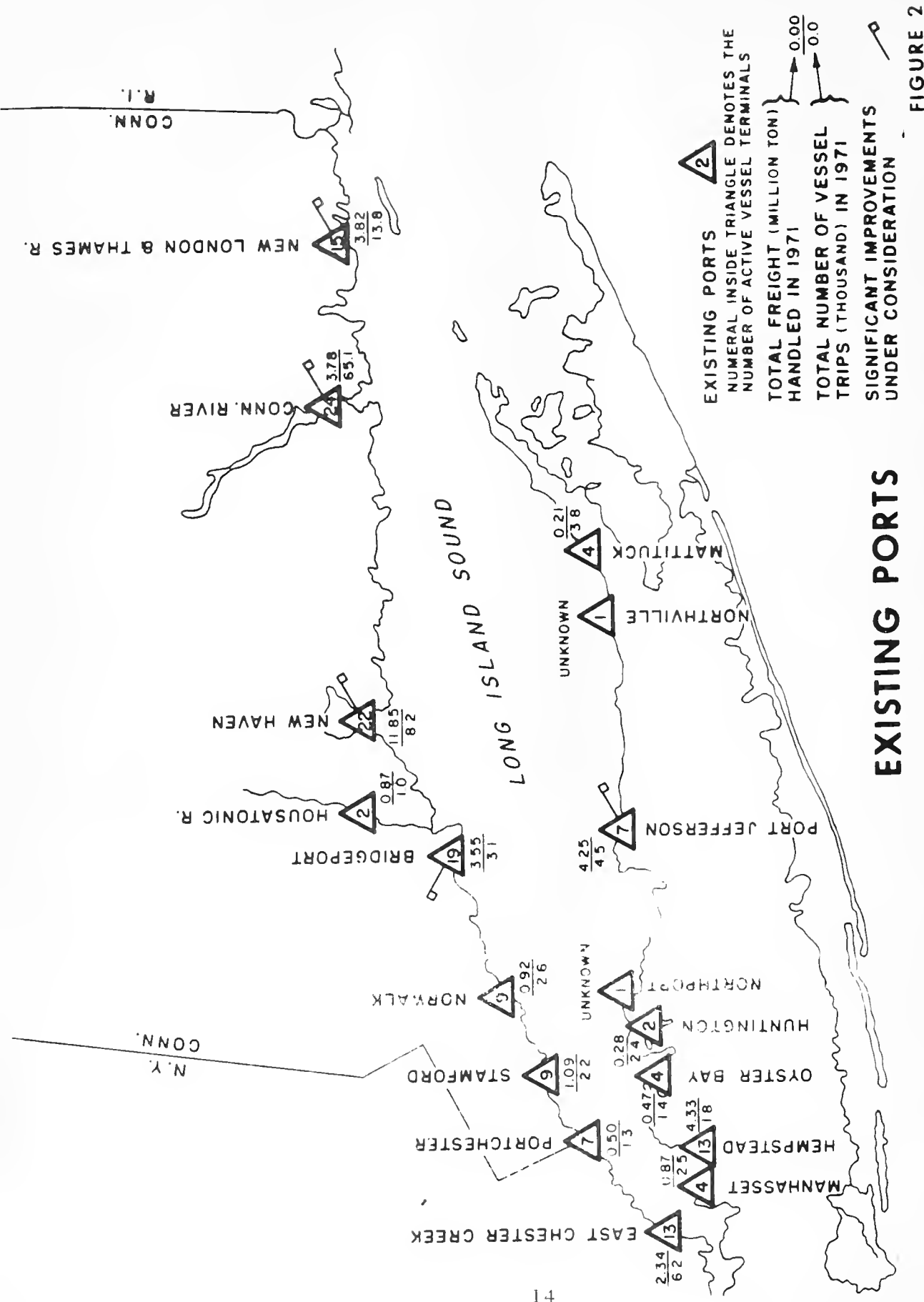
New London

Plans include expansion of general cargo facilities but no plan has been funded. Port proposals include upgrading and modernizing the State Pier, favorable relocation of some port facilities, and the replacement of existing ferries. The existing Federal harbor project dimensions are scheduled to be enlarged to provide a 40-foot entrance channel, 30-foot turning basin at the head of the channel, and a 32-foot maneuvering area fronting the State Pier. This project is now before the Secretary of the Army for consideration. Consideration has also been given to the possibility of an off-shore petroleum facility.

TABLE 4 - MAINLAND PORT COMMERCE/NAVIGATION INFORMATION

	NEW LONDON	NEW HAVEN	BRIDGEPORT	CONN. RIVER TO HARTFORD	STAMFORD	EASTCHESTER
Main Channel Depth/Width	33' X 600'	35' X 400'	35' X 400'	15' X 150'	18' X 200'	10' X 150'
Tidal Range	6'	6'	6'	-	7'	7'
Tonnage 1971	3.88 Million	11.9 Million	3.5 Million	3.77 Million	1.1 Million	2.3 Million
Commodities	Petroleum Lumber Textiles Molasses Chemicals	Petroleum Const. Mat'ls Chemicals Steel Scrap	Petroleum Metals Salt Steel Scrap	Petroleum	Petroleum Sand Gravel Steel Scrap	Petroleum Sand Gravel Cement Scrap
Market Area	Connecticut W. Massachusetts S. Vermont	Connecticut W. Massachusetts S. Vermont	W. Connecticut Massachusetts E. New York	Connecticut	S. Connecticut	Westchester County
Trends *	Increased Petroleum Traffic	4% Annual Growth	4.5% Annual Growth	3% Annual Growth	3% Annual Growth	2% Annual Growth
Limiting Factors	33' Depth	Silting to 31' Depth	Silting to 30' Depth	Ice/Flooding 15' Depth	Silting to 15' Depth	Barging Only
Facilities	4 Oil Terminals 2 Other	20 Oil Terminals 3 Other	12 Oil Terminals 7 Other	-	5 Oil Terminals 4 Other	8 Oil Terminals 4 Other
Environmental Problems	Spoil Disposal	Dredging Permits & Spoil Disposal	Spoil Disposal	-	Spoil Disposal	-

* Historical Average Annual Growth



Thames River

The Navy plans to deepen the existing 33-foot channel to 36 feet.

New Haven

Plans include:

- Conversion of municipal pier into a cruise ship dock and marina
- Construction of a new pier by Mobil Oil
- Consideration of storage tank expansion by Gulf Oil
- Increase of liquid bulk storage capacity by New Haven Terminal
- Construction of new fossil fuel generating plant by United Illuminating Company
- Corps study under way to determine need and justification for enlarging existing Federal harbor project dimensions
- Possible off-shore petroleum facility

Bridgeport

Plans include:

- 80-acre general cargo facility at Citgo Terminal wharf
- Replacement of Bridgeport - Port Jefferson Ferry
- Possible off-shore facility

Connecticut River to Hartford

In 1970, the Connecticut River Basin Report (15) for NERBC recommended a plan of improvement that included, in part, deepening the channel from 15 to 16 feet below mlw and widening the channel from 150 to 250 feet.

Long Island Ports. Major ports on Long Island include: Hempstead, Port Jefferson, Manhasset, and Northville. Pertinent commerce and navigational information concerning these four ports is shown in Table 5. Port facility expansion or improvement plans by public authorities or private sector are limited to two major projects, plus two relatively minor plans of little commercial significance. Known programs are as follows:

Hempstead

Upgrading of some petroleum facilities on a private scale is planned, but nothing that will affect the port commerce is expected.

TABLE 5 - LONG ISLAND PORT COMMERCE/NAVIGATION INFORMATION

	HEMPSTEAD	PORT JEFFERSON	MANHASSET	NORTIVILLE
Main Channel Depth	13'	26'	8' - 10'	67'
Tidal Range	4'	6'	6'	6'
Tonnage 1971	4.5 Million	1.2 Million	870,400	Not Available
Commodities	Petroleum 31%, Sand, Gravel, Cement 69%	Petroleum 86%, Sand & Gravel 14%	Petroleum 66%, Sand & Gravel 34%	Petroleum 100%
Market Area	Western Long Island	Central Long Island	Locally	Suffolk County Potentially all of Long Island
Trends	Constant Tonnage	Tonnage trippled last 10 years	Sand & Gravel Commerce to be Phased Out	Unsettled Pending Pipe Line Permits
Limiting Factors	Barge Traffic Only	-	Barge Traffic Only	-
Facilities	6 Oil Terminals 8 Other	3 Oil Terminals 2 Other	1 Oil Terminals	1 Off-Shore Terminal
Environmental Problems	Spoil Disposal	Dredging Permits & Spoil Disposal	Complying with Local Ordinances for Oil Importation	Permits to Build Distribution Pipe Lines

Source: Historical Average Annual Growth

Manhasset

The phasing out of a gasoline reception depot is contemplated due to difficulties in complying with environmental regulations.

Port Jefferson

One section of an existing oil pier was replaced in 1973.

Harbor development and expansion plans by local interests are being given serious consideration to provide a port capability to handle tankers up to 40-foot draft. At present, tankers are forced to lighter into barges prior to moving into the harbor causing congestion at the docks. The crunch occurs when storms prevent lightering in the Sound. Federal harbor project has not, as yet, been funded for design. However, local interests also endorsed two alternative plans for the importation of petroleum products: (1) west and east pipeline from New Jersey; (2) an off-shore terminal.

Northville

An existing off-shore oil facility is connected by underwater pipeline to a shore tank farm. The Nassau-Suffolk County Comprehensive Plan calls for a pipeline running from the Northville shore tank farm to the central corridor of Long Island. At present, Northville has no other plans for expansion.

3.2 Highway Transportation

Although waterborne transportation in the Long Island Sound region is of vital importance, it must be emphasized that movement of people and goods on the land in this region is an indispensable link in the economic and environmental chain. The LIS region depends heavily upon an extensive network of interconnected highways for land transport (See Figure 3). Commuter traffic is comprised mainly of automobiles. Waterborne goods are moved out of port facilities overland primarily by truck. In addition, trucks are the principal overland carrier both for bringing other goods into the area and for shipping out products manufactured in the LIS region. The alternative to massive highway freight movements -- an efficient rail freight system -- must be developed in the future. Unless rail transport is markedly increased, there will have to be significant increases in highway capacity in the New York City area and around major ports in the LIS region. The alternative is a highway system that will become woefully inadequate, with severe economic repercussions for the whole region.

In looking at any changes in land transportation in the region, however, one present major development has to be taken into account. Federal and

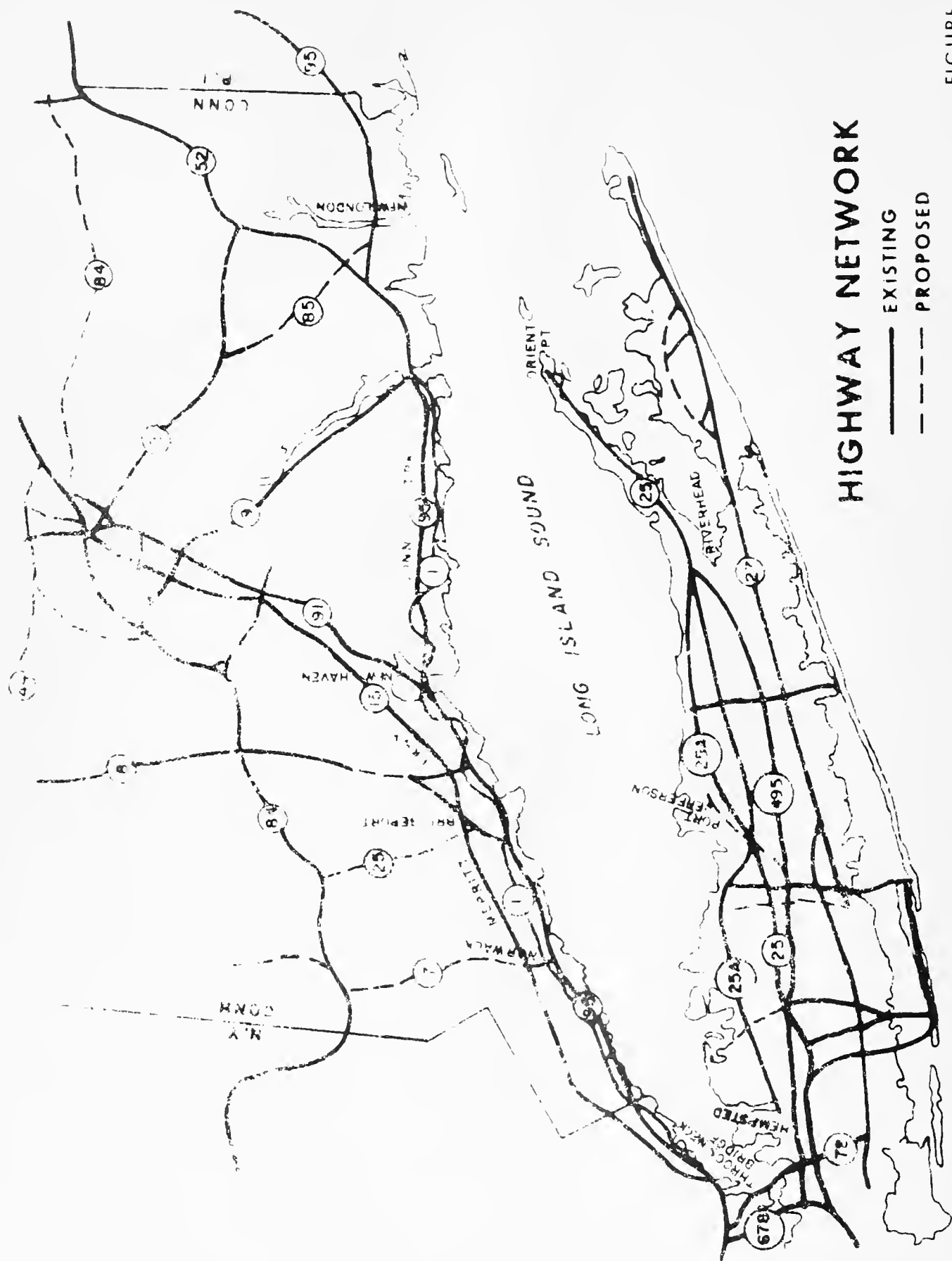


FIGURE 3

State environmental, transportation and planning organizations are beginning to look at the air pollution problem that encompasses the Connecticut shoreline from New York as far north as the Greater Hartford area. Transportation control strategies that evolve from their studies will in large measure give direction in the years ahead to all surface transportation decisions.

Acknowledging this development, following is a brief description of the major existing highways in the LIS region and some of the changes that are presently proposed.

Connecticut Mainland. In Connecticut, the major roads serving the corridor are the Boston Post Road (U. S. 1), the Connecticut Turnpike (I-95), and the Merritt Parkway (Route 15). At one time, the Boston Post Road was the "Main Street" of shore cities, as well as the principal link between them. Although the advent of the Connecticut Turnpike removed much of its long-distance traffic, this older road still carries a heavy load of traffic from adjacent commercial and industrial activity and from increased population. The Merritt Parkway, located three to four miles farther inland at the lower density edge of the urban area, is prohibited to commercial traffic and has a more circuitous route than the Turnpike. It therefore carries less traffic and at most times is less congested than the Turnpike.

Travel in the north-south direction consists mostly of shorter trips on arterial roadways. One major route is U. S. 7 from Norwalk to Danbury; the relocation of this stretch is a high priority State project. Reconstruction of another major route, Connecticut 8 from Bridgeport to Waterbury, is also being given top priority. Near New Haven, the Merritt Parkway becomes the Wilbur Cross Parkway and, together with I-91, turns north to provide limited access service to the spine of the urban corridor toward Hartford. Principal arterial service between New Haven and Hartford is provided by U. S. 5 and Connecticut 10.

East of New Haven, the Connecticut Turnpike and U. S. 1 continue to provide the bulk of the transportation service along the shore. With less urban activity in this area, the smaller arterial roads provide acceptable service to north-south and localized east-west travel.

Other changes proposed by the State of Connecticut include the Route 25 Expressway from Bridgeport to I-84 in Newtown, which will fill a large gap in the regional network and improve recreation opportunities. Construction of an expressway from New Haven to a point in the vicinity of Cheshire on Route 84 would support planned suburban growth, provide access to recreation lands, and promote equalized usage of the expressway system south of Hartford.

Most of the other proposed expressways are relatively short connecting links perpendicular to, and promoting more efficient use of, the major corridor routes. Additions would be warranted in the following locations: from New Haven to Route 8 in Derby; near North Haven; in Wallingford; and between Meriden and I-84 (Route 66).

Looking at the Connecticut highway system as a whole, it should be noted that, with few exceptions, the existing system is adequate -- for current traffic. However, increased population and employment, combined with rising incomes, would obviously generate more automobile use in the future. Also, if the preference for suburban development continues, the urban boundary will move further north -- placing much heavier loads on the Merritt Parkway. Increased activity in the coastal corridor, mostly local in nature, would severely overload the Connecticut Turnpike and the highways leading north from New Haven. As the corridor becomes wider, there will be greater need for improved roads to traverse it.

New York Mainland. In Westchester, the only proposed expressway improvement beyond those already under construction is an extension of the Cross-County Parkway to I-95.

Long Island. Long Island's major east-west highways are the Long Island Expressway (Route 495) and the Northern State Parkway. Both are located more than six miles from the Sound due to the relatively irregular north shoreline west of Port Jefferson and to the higher concentration of activities toward the middle and south of the Island. Routes NY 25 and NY 25A provide east-west arterial service in the area north of the freeways. Only two of the north-south freeways currently extend north of the Long Island Expressway, and most north-south travel is on surface arterials.

As is true everywhere, growth of population and income would cause major increases in highway travel. A large portion of Nassau County's growth is expected to be in the north shore communities. Most of Long Island's growth will be in Suffolk County, but this will put increased demands on highways in Nassau as well. The uncertain freight future in Long Island renders the economic role of the highway very significant.

Some changes presently proposed to improve Long Island's highway system include upgrading to freeway standards Route 347 between the Long Island Expressway at Hauppauge and Port Jefferson. As development moves east of Port Jefferson, an easterly expressway extension would be needed.

Improved north-south service, especially for commercial traffic, is also called for to supplement the existing parkway system. Such additional service may be warranted in the following areas: western Nassau County;

the Route 110 corridor; between Northport and Babylon; between Hauppauge and Islip; and between Port Jefferson and Patchogue.

Several locations for a highway crossing of the Long Island Sound have also been considered. A bridge between Rye and Oyster Bay has the greatest feasibility but no longer has State support. Several other locations have been outlined as well, such as Port Jefferson - Bridgeport, Riverhead - East Haven and Orient Point - Pawcatuck. In the more easterly locations, a combined highway-rail facility might be a fitting solution, but definitive studies have not been completed.

3.3 Petroleum and Natural Gas Pipelines

There are presently three petroleum pipelines serving the Long Island Sound region, all of which are near capacity; the Jet Line, the Buckeye Line, and the Northville Line. (See Figure No. 4.)

The only petroleum pipeline outbound from the Sound's north shore is Jet Lines, Inc., which runs from New Haven, Connecticut, to Springfield, Massachusetts. This is a 12-inch diameter line with a maximum capacity of 72,000 barrels a day. In addition to carrying jet fuel to Westover Air Force Base in Chicopee, Massachusetts, it carries petroleum products to distributors in towns through which it passes. The volume moved by this line in 1970 was about 7.9 million barrels, about one third its capacity.

The Buckeye Pipeline system, operating at least at half its capacity, consists of two 12-inch diameter parallel pipelines, carrying petroleum products from Linden, New Jersey, to Long Island delivery points, including JFK Airport. The only pump station on the present dual 12-inch system is at Linden, New Jersey. Maximum capacity of this pipeline system is 192,000 barrels per day of gasoline, Number 2 fuel oil, or jet fuels. Volume moved in 1970 totaled 33.4 million barrels.

On Long Island, Consolidated Industries operates a pipeline from a tanker pier at Port Jefferson Harbor to its terminal at South Setauket, then to Holbrook and Plainview. Northville Industries also operates a twin 24-inch diameter pipeline system from a mooring berth 7,200 feet offshore in Long Island Sound to storage tanks on the shore in Northville, New York. Northville's controversial 23-mile oil pipeline from Holtsville to Plainview recently opened for business. The No. 2 heating oil that the pipeline is to carry will run through the 16-inch pipe from Holtsville tank farm to a 500,000 gallon tank in Plainview, just off the Long Island Expressway. Bi-county plans include a further link, from Northville Industries' tank farm at Northville to Holtsville, but there is public opposition to this plan. Although the

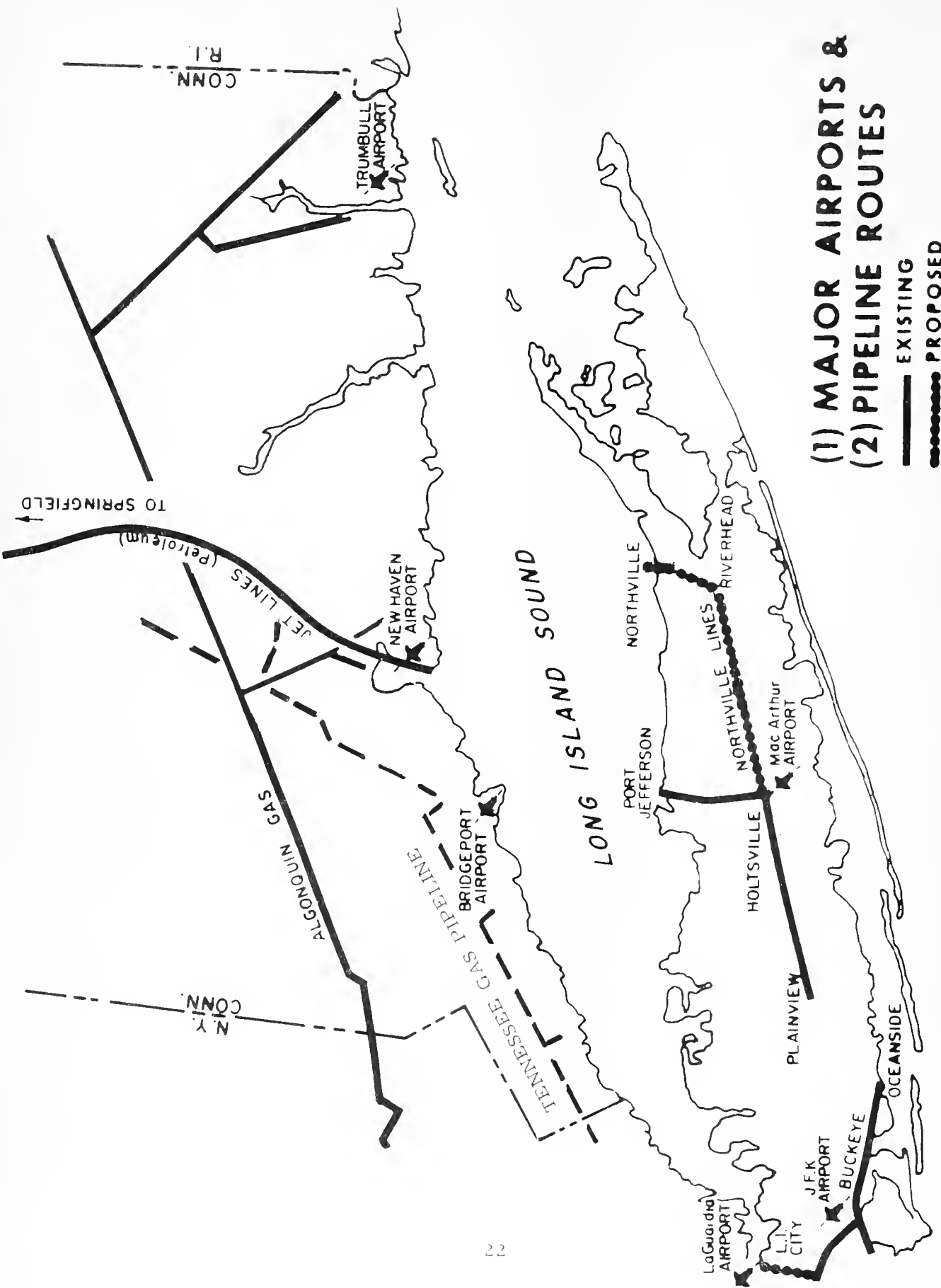


FIGURE 4

Northville Line is nowhere near capacity at present, there are limitations to its effectiveness. Port Jefferson's docking facilities are at capacity in winter, thus limiting an increased flow into the pipeline. Also, storage space at the Plainview tank farm is at capacity and near capacity at both East Setauket and Holtsville.

One other petroleum pipeline, known as Mobil 6, is indirectly relevant to the Sound region, although neither terminus is in the Long Island Study area. This line runs from East Providence, Rhode Island, to Springfield, Massachusetts, and might be considered to relieve some pressure on New Haven Harbor and the Connecticut River, since it serves the same area as Jet Lines, Inc.

Natural Gas Pipeline. The two natural gas pipeline in this region are the Algonquin Gas Transmission, Inc., which runs from Lambertville, New Jersey, to New Haven, Connecticut and the Tennessee gas pipeline.

3.4 Rail Transportation

Railroad lines in the Long Island Sound region presently are most important for the movement of passengers with the need for a return to and increase in rail freight service. Significant steps have been taken by New York and Connecticut to improve rail commuter service. Intercity rail passenger service is being improved by AMTRAK. There is need, however, for much better coordination between the two and for high speed service between New York and Boston along the Shore Line. (See Figure 5 for active railroad lines.)

In Connecticut freight operations have suffered a decline since World War II largely due to the construction of the Interstate Highway System, the practices of the Teamsters Union in opposing rail piggyback service and the public and private neglect of the national (or "interstate") rail system. These policies continue and have resulted in growing numbers of heavy trucks on our highways. More recently, the decision by the Penn Central to route Long Island and New England freight via Albany instead of by the more direct route on car floats across New York Harbor, and the incredible mass discontinuance of New York-Boston freight trains, has resulted in even more trucks on our highways. This is particularly true of I-95, where in the Norwalk area, counts of seven tractor trailers per minute (total east-west) are common. Late at night this rate increases to 10-12 perminute.

● INTERMODAL INTERCHANGE POINTS

ABANDONED RAILROADS

FIGURE 5

An increase of 30 percent in passenger travel demand projected for the Westchester/Connecticut corridor by 1985 will be partially served by existing plans for new rolling stock and improvements in right-of-way and in power supply. Exceeding this potential are the northeast corridor passenger recommendations for diverting travel from airlines and intercity bus and auto use. This implies increased concentration at station points.

Long haul truck freight should be shifted to the rails and New York-Boston piggyback service (popular for many years) should be resumed at once.

In addition, the Poughkeepsie Bridge should be reopened (closed since damaged by fire in May of 1974) and the Cross-Bay Union Freight Tunnel between Bayonne, New Jersey and Brooklyn, New York, proposed by the Port Authority in 1936, should be reconsidered in light of today's needs along with other suitable alternatives. This tunnel could close a gap in Northeast Corridor rail freight service and enable direct long distance piggyback service to Long Island and New England, to the direct relief of the Long Island Expressway and I-95.

The Tri-State Regional Planning Commission, in its preliminary Energy Saving Transportation Plan (June 1974) at page 23 urges the routing of carefully screened containers on freight cars through the Penn Station tunnels in New York City to provide direct, uninterrupted service along the Northeast Corridor to the benefit of Long Island and Connecticut.

On Long Island, the Long Island Railroad has a total of 334 miles of line and 270 miles of company sidings. The three inner branches of the Long Island Railroad provide commuter service to New York while the Greenport line, with its one daily train, serves mainly summer vacationers. The railroad, owned by the Metropolitan Transportation Authority, is plagued by conflicts over fare levels, labor and extent of subsidies, but commuter service is expected to improve with the completion in 1980 - 81 of a doubledecked tunnel at 63rd Street. The tunnel will provide for both transit subway and rail traffic linking the railroad to a new east side terminal in Manhattan

Freight service is important to some industries on the Island, but it averages only about two trains per week. Diversion of truck freight to railroad would be even more difficult than in Connecticut, since existing rail sidings are fewer and bridges are too low for "piggyback" freight. However, the Nassau-Suffolk Plan recommends a central spine of rail-oriented development which might increase the rail freight potential.

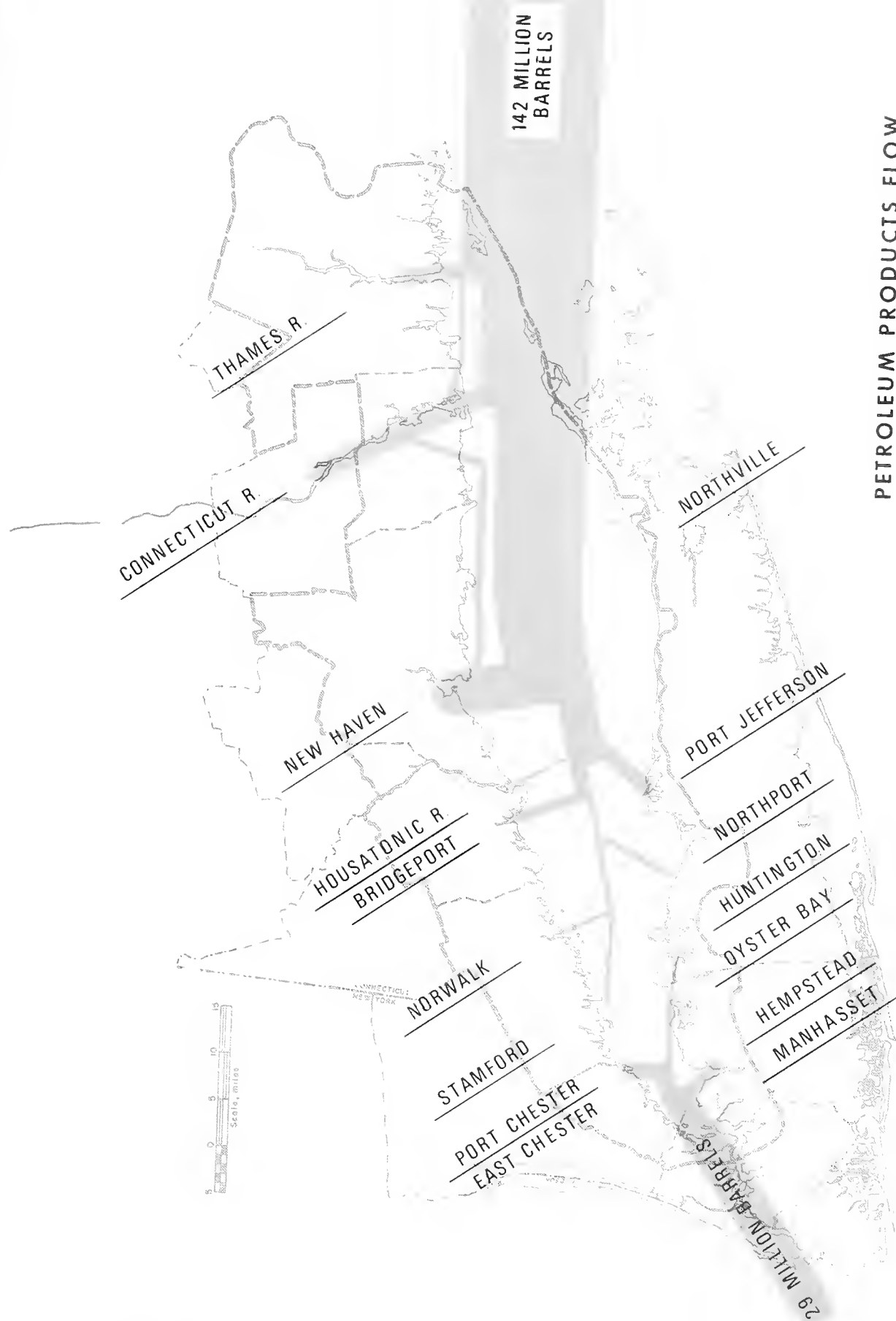
3.5 Air Transportation

There are three important commercial airports within the Long Island Sound Study region, transporting high-cost premium freight: Bridgeport Municipal, Tweed-New Haven and Trumbull. Figure 4 on page 20 shows the locations of these airports, as well as Kennedy, LaGuardia, and MacArthur, which lie just outside the Study area.

Two of the regional airports have expansion plans in various stages of development. At Bridgeport Municipal a 1,800-foot runway expansion will be necessary to handle the DC-9's that will comprise most of the Allegheny Airlines fleet in the future. Without the extension, Allegheny, the principal carrier, will have to bypass Bridgeport. The extension would be inland on property already owned by the airport, although 4-1/2 acres of wetlands would have to be filled. This expansion has been in the town plan for twenty years; however, the community of Lordship, in which the airport is located, has legal authority to block it. Residents of Lordship oppose any expansion believing that "this is only the beginning." Because of the legal restrictions, there is no timetable for the project.

A contract has recently been let to study airport expansion and modernization plans at Tweed-New Haven Airport. An extension of the main runway from 5,600 feet to 6,300 feet is being considered. This will include a taxi strip that will require filling of some freshwater wetlands. There are also plans to build a new terminal building and hangar facilities. The local citizenry are opposed to airports per se, in addition to the opposition to filling of wetlands. This project will not come in less than five years.

It is doubtful that any expansion will take place at Trumbull Airport, due to a study of the impact of the Airport that was recently completed by the Southeastern Regional Planning Agency and the Town of Groton Planning Office. Among the conclusions reached were that the airport has sufficient capacity for traffic in the foreseeable future and that no expansion is necessary. Particular emphasis in the report was given to noise.



PETROLEUM PRODUCTS FLOW

EXISTING 1971

SCHEMATIC

SEE TABLE 10 FOR VOLUMES

4.0 MAJOR UNRESOLVED PROBLEMS

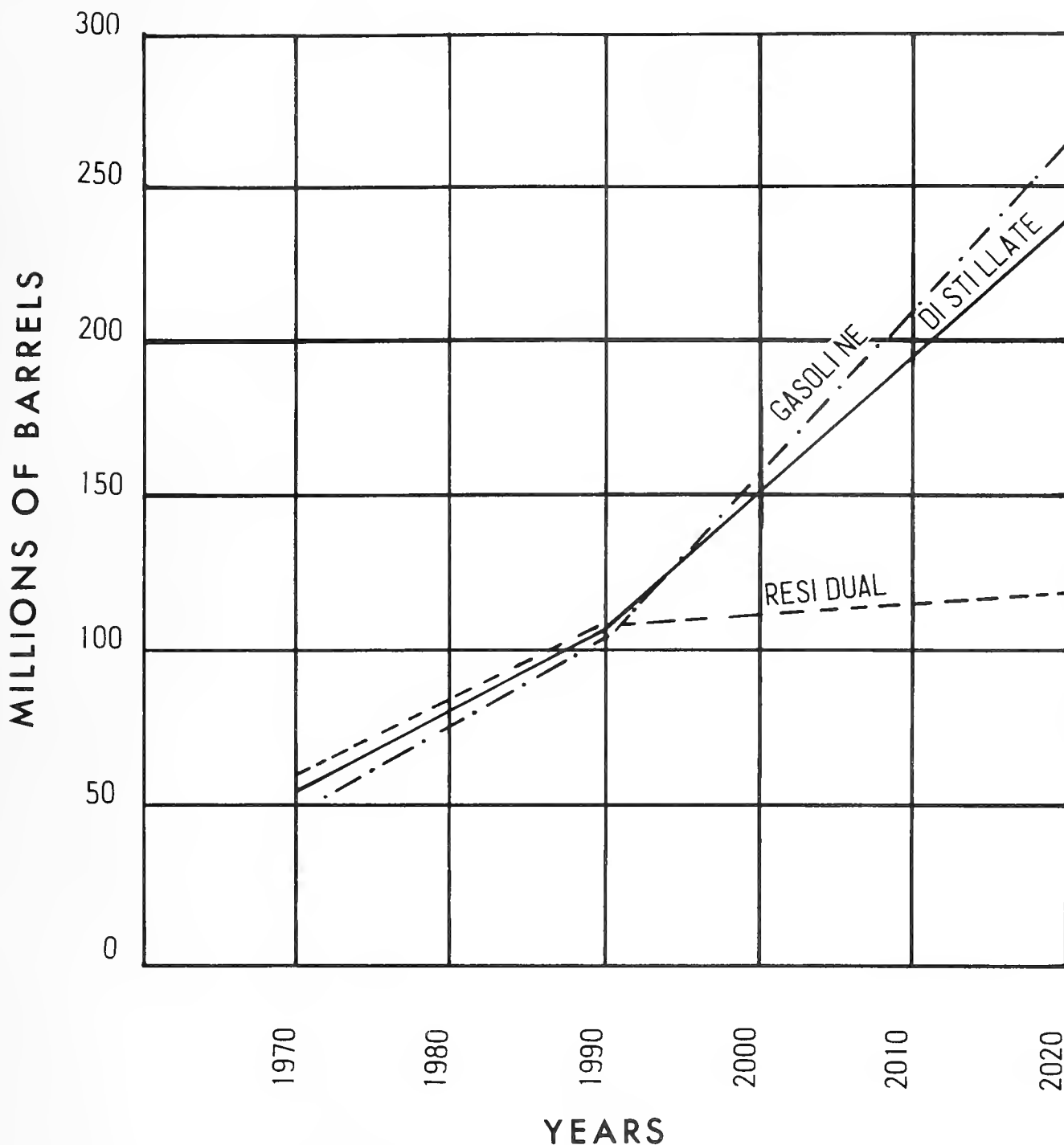
Virtually everyone in Connecticut and Long Island depends upon Long Island Sound for delivery of refined petroleum products that heat our homes and offices, produce electricity, fuel our industry and cars, and provide countless other essential services for our economy. Figure 6 depicts the 1971 product flow into and out of LIS ports.

Although petroleum products account for 80 percent of the commerce shipped on the Sound, several other commodities are significant as well. Construction materials - sand, gravel and stone - ranked second in volume. Other bulk cargoes, including scrap metal, lumber, and chemicals, are important at several of the ports as well.

If Connecticut and New York can combine lower LIS port costs with efficient dry bulk handling and competitive freight rates, it might attract a larger share of waterborne commerce in these commodities. Virtually every new concept in seaport design and cargo handling is aimed at moving more cargo or moving it more efficiently, or both. The trend of these new concepts thus tends to work against LIS ports when current dry cargo volumes are modest. At present, the ports also lack the necessary frequency of calls and the regular schedules required to support a major seaport, but these would be forthcoming if the cargo volume were there. Nevertheless, most ports will experience growth in bulk cargo receipts. For example, New Haven Terminal and Citco Terminal in Bridgeport handle over 1.7 million tons of bulk cargo per year. Their bulk cargo operations have a definite regional impact. "This impact is not only physical, as it must also be appreciated that handling such types of cargo contributes a financial benefit to the community three times in excess of that of handling petroleum products." (Source: USDC, Maritime Administration.)

Since petroleum products account for such a large proportion of the marine commerce in the Sound, and because they utilize and will continue to utilize the biggest ships, this study has focused on these products as the limiting factor in each port's development.

Demand for the three principal commodities - distillate (heating oil, residual oil (for power plants and industrial heating), gasoline - grew by more than 7 percent a year (compound rate) between 1958 and 1970, and is expected to average a 4.4 percent increase from 1970 to 1990. This exponential rate of increase would raise port receipts from 171 million barrels in 1971 to 321 million in 1990, and, if continued indefinitely, to over 600 million by 2020, as reflected by Figure 7. However, this growth is not expected to continue indefinitely. Even higher rates of growth outside the U.S. will rapidly deplete



Note: Oil projections, especially gasoline and distillate beyond 1990 may prove to be somewhat high. However, based on hard known evidence, the future development, widespread use, and timing of other energy sources are far too difficult to accurately assess at this time.

PROJECTED PRODUCT RECEIPTS

the world supply of crude oil, raising the price, forcing conservation and development of alternative energy sources - solar, nuclear, or some other form. By the year 2000, the U. S. should have peaked in its petroleum consumption, with alternative energy forms such as liquified natural gas, solar energy, coal and nuclear energy assuming an increasing share of the demand. Also, electric cars, car pools, an improved passenger railroad system, new and expanded subway and bus systems, the compact car trend, and other innovative schemes will undoubtedly further depress the need for oil.

Whether petroleum consumption will fall rapidly or simply level off is unclear. For purposes of planning we shall assume that demands will level off at our 1990 projected figures. This means more than doubling of present receipts. The attendant problems will be the focus of the rest of this section.

4.1 Navigation Limitations

General navigation conditions along the coastline's eastern and western approaches to the Sound and the region of the Sound are described here. Block Island Sound is a deep (85 feet to 120 feet) navigable waterway. It has two entrances from the Atlantic: eastern entrance between Block Island and Point Judith, and a southern entrance between Block Island and Montauk Point. The eastern entrance has an opening of 35 nautical miles with 85 feet to 120 feet navigable to tankers up to 400,000 DWT. The southern entrance, though wide, is rather complicated. Shallow spots of not more than 35 feet spread along the entrance and it is not advisable for navigating tankers larger than 20,000 DWT. Long Island Sound is a deep navigable waterway protected by Long Island from the action of seas of the Atlantic Ocean and from the powerful oceanic and littoral currents of the ocean fronts. This advantage can be proved by noting that the south coast of Long Island has practically no harbors of consequence.

The main entrance to Long Island Sound is on the east end. The entrance extends from the southern tip of Fishers Island to Little Gull Island, a width of about 3.5 miles, called the Race, named for its strong current. The main dangers here are Valiant Rock nearly in its middle and Little Gull Island with its reefs. The deep opening between Race Point and Valiant Rock is about 5,000 feet wide and has a depth of 150 feet or more. It is navigable for any size vessel the world builds and is the recommended route for tankers. In the middle of the Race, the strong current can go as high as 4.0 knots at flood and 5.2 knots at ebb. There are always rips and swirls in the wake of all broken ground in the Race, except for about 0.5 hour at slack water. The rips are exceptionally heavy during heavy weather, and especially when a strong wind opposes the current, or the current sets through against a heavy sea.

The west entrance to Long Island Sound is from New York Harbor through East River passing under numerous bridges and Hell Gate to enter the Sound. East River is the 14-mile long tidal straight which connects Long Island with New York Upper Bay. The Sound entrance is between Throgs Neck and Willets Point with a water depth of 50 feet. A Federal project provides for main-channel depths of 35 feet from Throgs Neck to New York Naval Shipyard and thence 40 feet to deep water in New York Upper Bay. Both sides of East River present an almost continuous line of Wharves. The Upper Bay entrance is between the Battery and Governors Island. Hell Gate, about halfway between Throgs Neck and the Battery, is noted for its strong tidal currents, crooked channel and heavy traffic. The current velocity in Hell Gate (off Mill Rock) is 3.4 knots for the eastward current and 4.6 knots for the westward current.

In the region of Long Island Sound, there are boulders and broken ground, but little or no natural change in shoals and the waters are well marked by navigational aids. As all broken ground is likely to be strewn with boulders, vessels must proceed with caution in the broken areas where the charted depths are not more than 6 to 8 feet greater than the draft.

In Long Island Sound the north and south shores are equally subject to fog, except that on spring and summer mornings, when there is little or no wind, fog will often hang along the Connecticut shore while it is clear off-shore and to the southward. All of the more important places in Long Island Sound are entered by dredged channels, and during fog, vessels ordinarily anchor until the weather clears before attempting to enter.

Drift ice, which is formed principally along the northern shore of the Sound under the influence of the prevailing northerly winds in winter, drifts across to the southern side and accumulates there, massing into large fields, and remains until removed by southerly winds which drive it back to the northern shore. In ordinary winters, ice generally forms in the western end of the Sound as far as Eatons Neck, in exceptionally severe winters, ice may extend to Falkner Island and farther eastward.

The major problems revolve around the above described navigation limitations including vessel trends and harbor facilities. None of the ports in the Sound presently has a channel deeper than 35 feet; most are much shallower. This leads to a dependence on small coastal tankers and barges for delivery. Poor training of some of these crews in oil spill prevention, the increasing number of vessel trips, and the lightering off-port tankers too deep to safely navigate silted-in channels have together greatly increased the possibilities of oil spills, despite recent State and Federal efforts at prevention and control. Unless major improvements are made in the receiving

systems, vessel trips and the attendant opportunities for spills will increase at the same rate as receipts.

Yet in order to enlarge navigation channels, dredging and subsequent disposal of materials must take place. The fear of environmental harm which these activities might cause has precipitated controversies the last few years over proposals to dredge in New Haven and New London and dispose of the spoil in the Sound. The region cannot afford to continue this recent history of prolonged delays of needed channel maintenance or deepening. Present monitoring of the effects of these two major projects must provide the answers regarding environmental threats and needed safeguards in future operations. As serious as this pollution problem may or may not be, it would probably be insignificant compared to the devastation of a major oil spill caused by a tanker running aground due to an inadequately maintained channel. The changing technologies in shipbuilding and the rapidity of these changes indicate that the existing deep-draft LIS ports will be inadequate to meet future tanker requirements. Growth in the cargo-carrying capacity of both tankers and dry cargo vessels has been on a steady rise since World War II, especially tanker sizes and capacities. In 1945, the standard size petroleum vessel was the 16,600 deadweight ton (DWT) "T-2" tanker having a loaded draft of about 30 feet. In 1950, the first U. S. tanker in excess of 30,000 DWT was built; and by 1956, eleven U. S. Tankers between 30,000 and 35,000 DWT were in service, having loaded drafts of about 35 feet.

The trend in world tanker construction continues toward larger capacity vessels. The average deadweight tonnage of oceangoing tank ships of 2,000 gross tons or more was 41,800 DWT at the end of 1970. This is compared to 20,200 DWT and 27,100 DWT at the end of 1960 and 1965, respectively. This represents a rise in average deadweight tonnage of 21,600 DWT or 107 percent during the past decade.

World tank ships on order or under construction in 1960 averaged 42,200 DWT. They increased to 51,000 DWT in 1965 and to 116,300 DWT in 1970. Of the vessels on order in 1970, about 65 percent were greater than the 50,000 DWT class, none of which could enter any LIS port.

By the end of 1965, there were only 19 tankers over 100,000 DWT in operation. By the end of 1971, there were no fewer than 366 tankers and 104 pure dry bulk and combination dry/liquid bulk similarly sized vessels. By the end of 1974, it is estimated that the operational world fleet of bulk vessels over 100,000 DWT will exceed 800 ships. Of this total, over 400 will be in excess of 200,000 DWT. By 1980, this massive fleet of bulk ships over 100,000 DWT is expected to exceed 1,000 vessels. Of particular interest on LIS, offshore facilities recommended in this report are expected to receive up to 150,000 DWT tankers carrying distillate oil and gasoline.

During the 1940's, the T-2 tanker was the determining factor in providing 35-foot channel depths at major U. S. ports. Because 35,000 DWT tankers require 40-foot depths, this necessitated enlargement of many harbor channels. Figure 8 shows the DWT-draft relationship for tankers in use or available for use today.

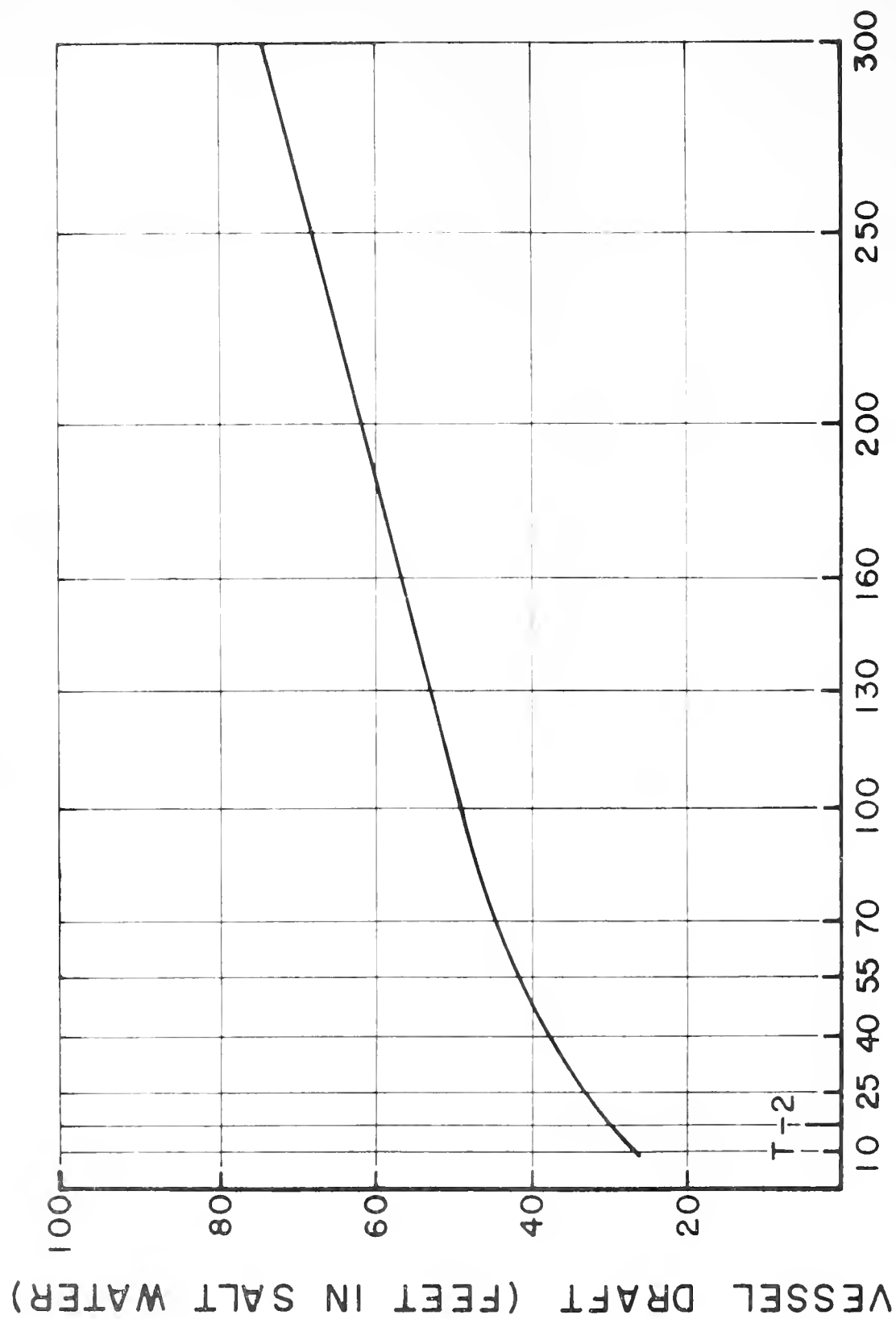
Just as important as these environmental threats caused by navigation limitations, is the additional economic burden on the consumer, who has to pay the penalty for small, inefficient product carriers. Enormous economies of scale can be gained by using new and larger vessels. However, present economic incentives offer far greater returns for use of supertankers for transporting crude oil than refined products. This is due to the distances the products are shipped and the lack of deepwater ports for product carrying vessels. Not until deepwater ports are available to serve major market areas such as the LIS region, will industry begin to use its fleet of large, new product-carrying tankers.

4.2 Inadequacy of Harbor Facilities

Problems on land and in the harbors can also hamper the efficient and environmentally sound handling and distribution of products. Products are currently received at 17 ports around the Sound, seven in Connecticut and ten in New York. The proliferation of small harbors leads to conflicts between the industrial waterfront development and the often predominant residential or recreational use of the waterfront. It also leads to additional dredging and increased chances of oil spills. In most cases the handling and storage facilities are located right at the water's edge, adding to the possibility of spills. But oil storage tanks could be located inland just as well without precluding other water-dependent or enhanced uses of that land, and without adding a visual blemish to what should be the most stimulating area visually in the urban communities.

In many of the harbors, conflicts are also apparent between commercial and recreational vessels. As the popularity of recreational boating climbs, much more boating opportunity, particularly in the protected bays, could be provided if commercial traffic were eliminated. This is especially true in the bays on Long Island.

Some of the ports, especially the lower Connecticut River and Cold Spring Harbor, are blessed with such beautiful, unscarred waters and shores than any industrial activity or accidental oil spillage would seriously degrade the natural beauty of these areas. In the Connecticut River a major oil spill might temporarily cripple tourist trade, that region's most important industry.



TANKER SIZE - THOUSANDS OF DEADWEIGHT TONS

VESSEL DRAFT VS. DEADWEIGHT SIZE

4.3 Traffic Congestion

Product storage at the waterfront also leads to problems of traffic congestion and noise pollution as trucks try to enter the principal highway arteries in the cities. On Long Island, most of the highways don't lead right to the harbors, often forcing the trucks to use local roads that were never designed to accommodate their numbers and size. The result of this congestion is added time and expense in product delivery.

Presumably, some of the present highway congestion could be relieved if people and commerce moving between New England and Long Island had some reliable alternative route than across one of the East River bridge crossings. But the two existing ferry lines operating Bridgeport to Port Jefferson and New London to Orient Point have very small, slow vessels, closed for several months a year, offer no reservations, and usually require vehicles to line up at least an hour before Launch time in order to get on the next trip. However, until the Rye-Oyster Bay Bridge proposal was finally defeated, ferry operators foresaw a rather dismal future for themselves. Without the threat of competition from a bridge, the quality of the ferry service should improve markedly in the near future.

4.4 Public Opposition

As urgent as the physical, environmental and economic problems involved are, any development plan related to petroleum movements on the Sound creates an atmosphere of public concern. Whether because of skepticism, concern about public funding, or lack of specific information, people today are leery of talk about pipelines, new storage centers, off-shore drilling, dredging, off-shore berth or anything else they know can have major impact on their environment. They demand explanations of any plans to change the Sound area and their questions must be answered.

5.0 PLANNING OBJECTIVES

With the above problems in mind, the following planning objectives were chosen:

A. To minimize the number of trips by oil tankers and oil barges in- to and out of the rivers and harbors of Long Island Sound.

B. To reduce the amount of shorefront land area for oil tank farms and oil handling facilities.

C. To alleviate the congestion of the highway distribution system at the major oil ports.

D. To find environmentally and economically acceptable methods of dredge spoil disposal.

E. To facilitate the continued adequate and safe movement of dry cargo products and people.

6.0 ALTERNATIVES

Although the emphasis of the planning was on ways to lessen the environmental impacts of the marine transportation systems, all alternatives were evaluated just as thoroughly for their economic and social acceptability. The following alternatives were considered first generally, and then with respect to each port.

Receiving System

1. Channel maintenance
2. Channel improvements
3. Offshore berth
4. Pipeline from outside the region
5. Vessel modification
6. Offshore unloading from vessels

Handling System

7. Expansion-modernization of existing facilities
8. New inland storage centers
9. Consolidation of existing storage

Distribution System

10. Pipeline
11. Truck

People Movements

12. Ferries
13. Hovercraft
14. Hydrofoils
15. Bridges

Several of the alternatives were dismissed after only a very brief evaluation. For example, bringing oil into the region by pipeline from outside was dropped because of extremely high costs and social disruption from using a pipeline originating in New Jersey, as well as the limited capability of the refining complex there to expand to serve much of the LIS region. If a refinery were established in southern New England, it might well serve Connecticut by pipeline and eliminate most of the tanker traffic in the ports. However, there are no signs yet that a refinery would be welcome in this area, so this plan has made the assumption that there will not be any new refineries in or close to the LIS region.

If, on the other hand, several refineries were eventually constructed, particularly in the southern New England area, sufficient refinery capacity would probably be available to service most or all of New England. In that event, sea and land petroleum distribution patterns would significantly change. This report's plan to bring in oil products via vessel to key LIS ports would be reconsidered. Pipelines to the LIS area might be considered as viable alternatives.

Vessel modification through lengthening and widening ship dimensions without deepening was found not feasible on a large scale due to navigational instability, navigational limitations such as narrow channels and bridge openings and limited turning basis, and inability to compete economically with new, larger vessels.

A method which would minimize capital outlay and take advantage of all existing port facilities, is offshore unloading from vessels in the 150,000 DWT class to smaller vessels and barges for transshipment into the ports. The numbers of large carriers and lightering operations would increase annually as the demand for petroleum increases. A plateau point would be reached, however, when existing port facilities would be unable to handle the large number of barges that would be involved in the transshipping operations. The increasing numbers of vessels and transfer operations would increase the probability of future oil spills. Past studies show that increased congestion due to lightering operations could significantly increase the likelihood of larger spills at existing ports. The amount of oil spilled has been estimated at 0.5 barrel per million barrels transferred. Because smaller

vessels require a greater number of transfer operations for an equal volume of oil, the spillage rate for smaller vessels is higher - about 0.7 barrels per million. Although transshipment from large offshore oil carriers may be practicable over short-term periods, this method of supplying terminal facilities would be incapable of meeting mid and long term needs.

Consolidation of shore facilities within a particular port, especially for oil storage tanks, seemed to have no advantage other than a slight environmental one. Relocation away from the shorefront, however, evaluated separately under the alternative of new inland storage centers.

The possibility of hydrofoils and hovercraft was also dismissed, primarily due to conflicts with recreational boating. A vessel traveling at 40 - 50 knots, even if it did not create a wake, would require its own restricted traffic lane, thereby limiting movements of pleasure craft in one of the most popular recreational boating areas in the world.

Consideration of a new cross-Sound bridge was also dismissed since the only route with economic feasibility, Rye to Oyster Bay, has been rejected due to public opposition and to possible future adverse effects on vessel traffic, marine environment, and energy use. The Governor of the State of Connecticut has also expressed opposition to any bridge across LIS which touches down in Connecticut or which would have significant adverse impacts on its transportation system.

An evaluation matrix has been developed concerning environmental, economic, and social criteria, totaling 45 items. This criteria was systematically compared with each transportation alternative. On this basis, a rating (poor, fair, good) was given to each alternative and a judgment made that led to tentative NED-EQ recommendations. The summary of these findings is shown on Table 6.

This table was not intended for use in justification of any particular proposal, but merely as a generalized assessment. When applied on a site-specific basis, some of these evaluations will undoubtedly change.

7.0 EVALUATION OF ALTERNATIVE MEASURES

In order to develop an integrated plan for the whole LIS area, this report looked at the region first in terms of market areas, a breakdown which necessitates some overlapping in discussion. In this section, present and future product flows for each market area, or subregion, are evaluated and all possible alternative plans considered. As a result, the 1990 possible change in the flow of refined oil products proposed for the region as a whole is presented in Figure 9.

The LIS area, totally lacking crude oil refining capacity, must rely upon outside sources for its refined petroleum products. Trade patterns are shifting more and more from the Gulf Coast and Caribbean ports to the Persian Gulf. This changing source for crude oil and refined products represents an increase in travel distance of about 19,000 miles and in travel time of about 50 days. If this trend continues, greatly increased numbers of shallow draft vessels would be required to transport more oil over these greater distances. Another implication of increased shipping distances is that present thru-put storage ratios, such as 12 to 1 for residual fuel, will not provide sufficient reserves to accommodate interruptions in the supply line even for short periods of time. Recently, orders have been given to utilities to increase oil reserves from 29 days to at least 40 days. This travel, if continued, will foster the need for more storage and coupled with an expected increase in demand, require even more. The existing harbor-port receiving, storing and transfer facilities and the associated pipeline, tank truck, and railroad tank car distribution systems will not be capable of efficiently handling the 620 million barrels of waterborne petroleum products projected for consumption in the LIS area through 2020. Therefore, greatly improved methods of moving refined products will be required to service this region's growing population and insure a high standard of living, without causing environmental harm.

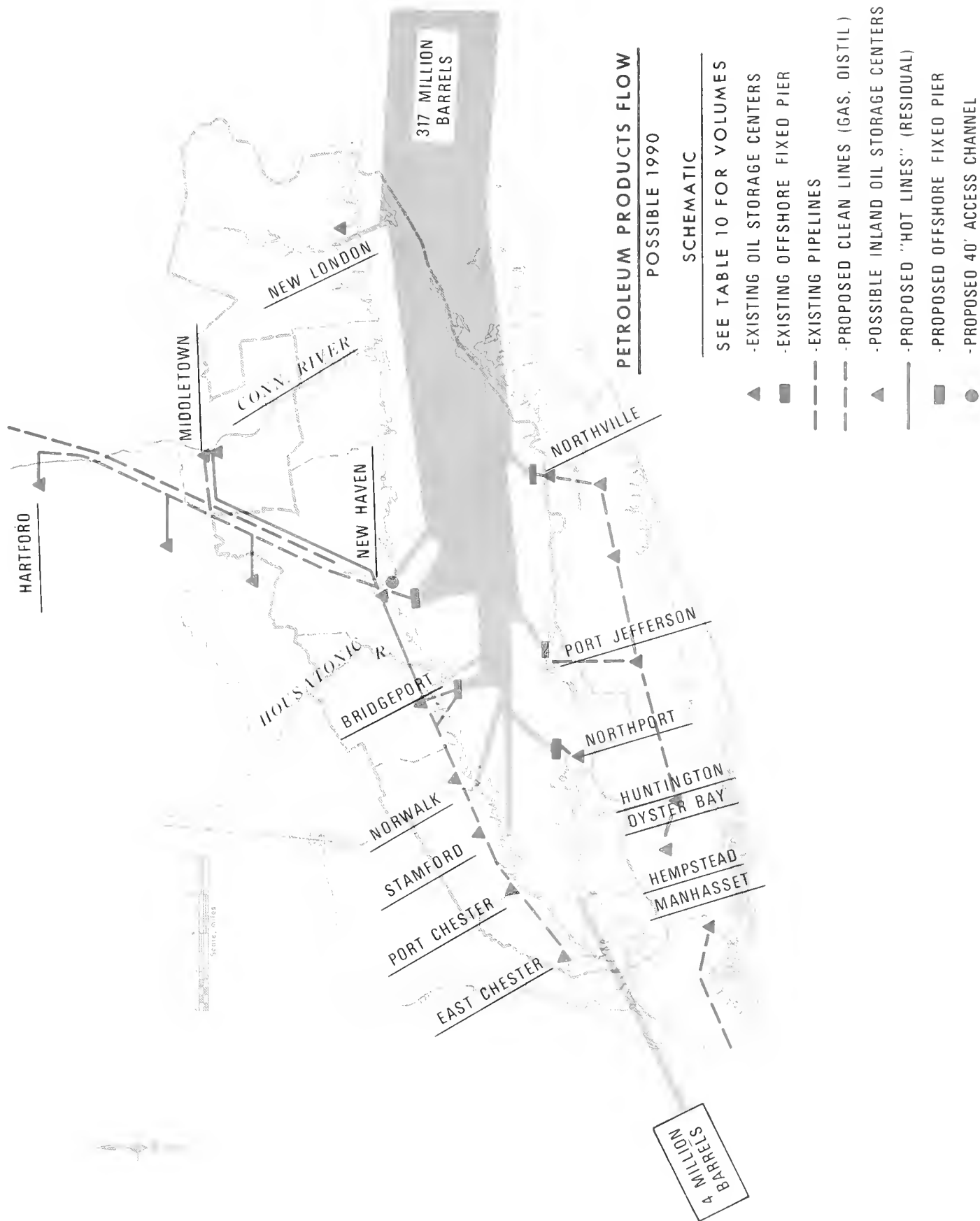
The magnitude of cost for initial construction of planned oil receiving and handling systems, considered necessary to meet LIS area marine transportation requirements, has been set at 414 million dollars. A breakdown of planned improvements and costs, by subregion, is presented in Table 7 of this report.

7.1 Subregion 1: New London Harbor and Thames River

The transshipment of millions of barrels of residual oil is the major problem facing New London Harbor. Of its present receipts of 11.4 million barrels, only 2.3 are actually consumed in the port's market area.

TABLE 6 SUMMARY EVALUATION OF MARINE TRANSPORTATION ALTERNATIVES

Evaluation Criteria	Do Not Meet Needs	Channel Improvements	Receiving		Offshore Berth	Handling		Distribution		People Moves	
			Channel Maintenance	Expansion/Modernization		Island Centers	Pipeline	Truck	Ferries		
Environmental	Fair	Poor	Poor	Poor	Fair	Fair	Fair	Poor	Fair	Fair	Fair
Economic	Poor	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Fair	Fair
Social	Poor	Fair	Fair	Poor	Good	Good	Good	Poor	Good	Good	Good
Applicability to alternative plans	None	ED	ED	None	EQ&ED	EQ&ED	EQ&ED	None	EQ&ED	EQ&ED	EQ&ED



The rest is transshipped via barge to supply such power plants as Montville, Middletown and Hartford, which together consume 75 percent of the total residual oil received at New London.

The magnitude of the impact on present receiving, handling and distribution systems perhaps can be seen by looking at the number of vessels needed to move such volumes of oil. In 1971, 1,300 inbound oil barge trips were recorded on the river; at least 400 of these originated at New London Harbor. By the year 2020, projected oil barge trips are expected to reach 3,200, with New London contributing about one-third, or 1,100. What's more, if present practices continue, the number of inbound vessel trips may be expected to skyrocket from today's 600 to about 3,700.

On the Thames River, demand projections indicate greater receipts in distillate fuel and gasoline. Although industrial and commercial demands for residual oil may produce only a 3 percent average increase per year, it is anticipated that by 2020 distillate and gasoline will be four times and six times the present day flow, respectively. At the same time, upbound oil barge trips are expected to total close to 400, five times more than the present trip number. These additional quantities and additional barge trips are bound to place a burden on present receiving, handling and distribution systems.

In addition to the large volume of petroleum moved in this subregion, dry cargo also increases the vessel traffic. At New London Harbor, which handles products for the Pfizer Chemical Company and general cargo at the State Pier, dry cargo vessel trips actually outweigh those of oil tankers and barges. This does not include ferry traffic and many trips made by U. S. Naval and Coast Guard vessels.

In light of the above, the major change contemplated for this subregion is discontinuing transshipment of residual oil via barge from New London Harbor. Tentative plans call for transporting the oil destined for Connecticut River terminals in larger vessels directly from the supplier to New Haven Harbor. Also recommended for New London Harbor is deepening and widening the Federal navigation facilities opposite the State Pier.

With the resulting decrease in petroleum receipts in the harbor by 1985, it is anticipated that deepening the present channel from LIS to the Navy's submarine pens in the Thames River from 33 to 36 feet will be adequate for future traffic, consisting of larger tankers carrying about 40,000 tons and entering the port only three or four times a month. The alternative to the 40-foot channel - an off-shore mooring facility - is dependent upon the future commercial development of the area.

On the Thames it is expected that barge traffic will continue to be the chief method of product transport but that deepening the present 25-foot channel depth is not required. Instead, it is recommended that the upper tidal river channel from the submarine pens to Norwich be maintained at whatever depth is required for future traffic needs.

To meet the increased distillate and gasoline flow, particularly to the Norwich area, it is recommended that riverfront storage centers be expanded to hold 0.8 million barrels. The Amerada-Hess shorefront facility at Groton presently stores almost all the residual fuel moved in the area. With the decrease in residual oil flow, Hess' tanks could be converted to store the "clean" products of gasoline and distillate, thus reducing the number of new storage facilities needed for the area.

7.2 Subregions 2, 3, & 4: Connecticut River below Hartford and New Haven Harbor

Receiving, handling and distributing millions of barrels of residual oil is a massive, three-pronged problem for New Haven Harbor and the Connecticut River.

In 1971, nearly 17.5 million barrels, including 90 percent foreign oil, entered New Haven Harbor, whose present channel depth is 35 feet. Tankers of all types, including those with a loaded draft of 39 feet, made more than 3,600 trips into and out of the harbor.

The large volume of movement in the port is due to the fact that millions of barrels of residual oil are transshipped out of the harbor by rail, truck and barge. Of the 17.5 million barrels received, approximately 2 million barrels were transported by railroad tank cars to power plants at Springfield, Massachusetts. Tank trucks carried 1.7 million barrels to the power plant at Devon on the Housatonic River and 9.6 million barrels to the New Haven and inland market areas for use in industrial and manufacturing plants. Further, over 4.2 million barrels were transshipped by tank barges and smaller coastal tankers to ports west of New Haven and up the Connecticut and Housatonic Rivers, including the New Haven power plant on the Mill River.

Combining the oil transshipped from New Haven and New London Harbors, the Connecticut River was the pathway in 1971 for approximately 500 upbound and 500 downbound tankers, transporting over 8-1/2 million barrels of residual oil. Most of the oil went to storage facilities at the Middletown and Hartford power plants; the remainder was used for heating local industrial and manufacturing plants.

Projecting the demand for the residual oil required on the Connecticut River at 18 million barrels by 1990 and 31 million barrels by 2020, if the present-day system of carrying oil up the Connecticut River is continued, the number of vessel trips will be nearly 2-1/2 times greater by 1990 and over 3-1/2 times by 2020. Although the power plant at Hartford is to be closed soon because of the plant's old age, the power plant at Middletown is to be expanded substantially. Therefore, most of the future vessel trips will be to Middletown. Trips to Hartford will still increase, however, but at a decreasing rate, due to the need for heating industrial and manufacturing firms.

It will also be difficult to find urban land for additional tank storage, which will increase in proportion to the number of vessel trips, and to find ways to handle additional tank truck traffic to local industry.

When the projected quantities of distillate and gasoline guels, as well as other commodities, are added to the projected amounts of residual fuel anticipated in New Haven Harbor and on the Connecticut River, it is abundantly clear that the present transportation systems should be changed. (See Table 10, page 67.)

New Haven Harbor is the chief source of gasoline and distillate going up the Connecticut River and of that distributed to the coastal and inland market areas. From New Haven Harbor and the waterfront storage tanks along the river, distribution of both these fuels is primarily by tank truck. In the case of gasoline, trucks go directly to the individual gas stations. Distillate fuel is delivered either directly to the homeowner or to intermediate inland storage tanks and then to the homeowner. Inadequacy of scattered storage tanks and increased traffic congestion due to tank truck distribution are two of the major problems that result from the present system.

In analyzing the subregion as a whole, a major change in the flow of oil products has been proposed: reduce or totally eliminate oil traffic on the Connecticut River. The deciding factors in this decision were:

1. To accommodate present vessel traffic, frequent dredging and maintenance of training walls and spur dikes are required.
2. Although dredging must be done, spoil disposal sites are practically extinct. There are very few areas on the river below Hartford and hauling by barge to Long Island Sound (if permitted) would be expensive and time consuming.
3. EPA standards regarding vapor emissions and leakage into groundwater supplies have closed some gas storage facilities and thus reduced gas barge traffic.

4. Commercial and recreational vessel traffic, as well as truck traffic, is steadily increasing at various receiving ports.

The most environmentally, economically, and socially feasible alternative to river transport of oil is pipeline.

In the case of residual oil, a pipeline from New London Harbor, source of most of the residual oil, is not economically viable because of lack of right-of-way and high cost. A pipeline up the Connecticut River would require the construction of an oil-receiving port at Old Saybrook or an off-shore terminal. These are both very costly and impractical when advantage can be taken of the existing 12-inch diameter pipeline, extending from New Haven Harbor to Hartford and Chicopee, Massachusetts, within the Penn Central Railroad right-of-way.

It is recommended, therefore, that residual oil be brought directly into New Haven Harbor. Since residual oil must be heated before it can be pumped, a heating plant would have to be built in the port area and insulated pipelines - or "hot lines" - be provided to transport, by 1985, close to 38 million barrels of oil primarily to satisfy New Haven and Middletown power plant needs, and to a lesser degree, for the industrial and commercial heating needs of Connecticut's central north-south corridor; i. e., New Haven to Hartford and vicinity. These lines, along with tank farms to supply local industry and manufacturing, should be completed by 1985. Justification can also be made for extending the pipeline from Middletown to the Hartford area by the year 2020, since by that time its industrial and commercial heating requirements will have reached 4.3 million barrels.

In addition to instituting the pipeline to New Haven Harbor, the number of tanker trips on the river would be kept to a minimum by deepening the existing 35-foot channel to 40 feet, permitting the general use of at least 50,000-ton tankers.

An off-shore facility was considered to reduce port vessel traffic but this would not be feasible for receiving residual oil, which can be piped only 1 - 2 miles under water before reheating. The facility would have to be five miles off-shore - too great a distance to pipe this oil without reheating.

Gasoline and distillate, on the other hand, do not have to be heated for transport; thus an off-shore facility south of New Haven Harbor is recommended to receive up to 150,000-ton tankers carrying distillate and gasoline. The fuels would be transported from the mooring facility via two separate pipelines to New Haven and then Hartford. Such a system would reduce the vessel traffic in New Haven Harbor and all along the Connecticut River,

thus minimizing environmental as well as economic problems. The cost to improve the existing Jet Line, New Haven to Hartford to carry maximum capacity about 24 million barrels per year, is expected to be more costly than providing a new line to do the same work. As a result, the Jet Line by 1990 is expected to be phased out. Harbor area truck traffic would also be decreased by providing consolidated inland tank farms in such possible vicinities as New Haven, Meriden-Middletown, and Hartford. This action would move the distribution centers away from the harbors.

7.3 Subregions 4,5, & 6a: Housatonic River to East River

Subregions 4, 5, & 6a consist of about forty nautical miles between the Housatonic River and the East River, at the western end of the Sound. Within this westerly mainland reach are six coastal harbors or rivers engaged in commercial waterborne commerce: Bridgeport Harbor, Norwalk Harbor, Stamford Harbor, Port Chester Harbor, East Chester Creek Harbor, and the Housatonic River.

The first three harbors - Bridgeport, Norwalk, and Stamford - have electric power plants that required a total of 11.1 million barrels of residual oil in 1971, a majority of the oil shipped into their ports.

At Bridgeport, which has two plants, a large percentage of the oil is brought in by tankers drawing 20 - 30 feet. Although the storage capacity at both plants is small, there is a large harbor oil storage center located adjacent to Johnson Creek, over a mile from either plant. This storage center has ample capacity for present needs. Currently, oil is transported from the center to both power plants by special heated tank truck and barge. Small quantities of residual are also sent to industrial plants in the area and used for heating facilities. Although good water and highway access is available, transshipment volumes at Bridgeport are high and the impact on both routes is intense.

The power plant in Norwalk Harbor, located at Kyser Point near the harbor entrance, receives most of its oil by 5,000-ton barges with a draft of 16 feet. Since water access to the plant is by the harbor's main 12-foot channel, vessels drawing 12 feet or more must lie and wait in the Sound for favorable tidal conditions before entering. Storage capacity at plantside is probably not more than 60,000 barrels and at the harbor not more than 75,000; therefore, the facility relies heavily on a steady in-bound product flow. Storage capacity for oil used by industrial and commercial facilities in the area, about 15,000 barrels, is available at harborside and considered adequate to meet present day needs. Since oil consumption at this plant is expected to decrease, any additional storage capacity needed will not require new construction. The present practice of storing at Bridgeport and New Haven can be continued.

On the other hand, the Stamford power plant, which consumed 60 percent of the 1/2 million barrels received by barge in that harbor, is expected to expand and cause a sharp increase in residual fuel consumption. Although present storage at plantside and in the harbor area occupies only two acres of shorefront land, it is ample for current needs. As oil consumption increases, however, additional storage capacity will have to be provided near the plant or at some other port. Distribution from portside, as in Norwalk, is by special tank truck.

With the exception of the Housatonic River, all of the ports in this subregion have heavy traffic in distillate and, all but Norwalk, in gasoline. In the case of Bridgeport, the fuels are brought into the 35-foot deep channel by deep draft tankers. The other five ports receive the fuel by tank barges and small coastal tankers, resulting in over 2,300 inbound vessel trips in 1971. Distribution of the products from the harbor storage tanks at each port is solely by tank truck - in the case of distillate, directly to the homeowner or to intermediate inland tanks, and in the case of gasoline, directly to individual gas stations.

Other products are received at all the ports but only Bridgeport receives and handles a large volume - over 300,000 tons of products other than petroleum - with close to 700 dry cargo inbound vessel trips recorded in 1971.

As in the other subregions on the mainland side of the Sound, the findings of this study indicate that pipelines must be used to reduce heavy vessel traffic along the western section. In the case of residual fuel, it is feasible, economically sound, and environmentally advantageous to provide in 1985, a "hot oil" Pipeline System about four miles long, from, possibly, the Johnson Creek storage center at Bridgeport to the Devon power plant on the Housatonic River. Although there may be some objections, such a plan would ultimately eliminate the present three pronged cumbersome effort of supplying residual oil requirements to the Devon plant. Namely, the 2.3 million barrel transshipment operation by barge and the 1.7 million barrel transshipment operation by tank truck from New Haven to Devon, thirdly, the 50,000 barrel transshipment operation by barge from Bridgeport Harbor to Devon.

The power plants at Stamford and Norwalk do not use enough fuel to justify extending the hotline any farther west. It is recommended that future residual supplies be barged directly into the harbor terminals.

To decrease distillate and gasoline vessel traffic, it is recommended that an off-shore facility comparable in size to that off New Haven be constructed near Bridgeport Harbor. Dredging the shallow harbors to 30 or more feet to allow for small tankers was considered but the cost of such

extensive dredging would be prohibitive, disrupt shore facilities and require disposal of spoil into the Sound. The planned off-shore facility could receive the 50 million barrels projected for all six ports by 1990 and then transport this fuel through two pipelines to tanks in the port of Bridgeport. However, the timing for the off-shore berth near Bridgeport has been tentatively set for the year 1995. Not because it couldn't or wouldn't happen sooner, but because, time will be needed to carefully assess the many impacts on Connecticut's first off-shore berth operation and its first major pipeline system with attendant storage and handling facilities. Evaluation is necessary concerning the relief this proposed system offers other modes of transportation, in particular truck movements to and from ports.

From the harbor, or directly from the off-shore berth, the fuel could be piped for distribution to common tank farms at convenient inland locations. A problem exists in this link in the system because there is no existing pipeline along the western mainland and a right-of-way must be found. There are several possibilities, however: the Penn Central Railroad right-of-way; the Connecticut Turnpike right-of-way; and an underwater pipeline to storage tanks on the shore of the Sound. This latter alternative is more expensive and more environmentally dangerous.

Because of the need to assess the environmental and economic impact on the region resulting from the proposed off-shore facility and pipeline system, the timing for the project has tentatively been set for the year 1995.

7.4 Subregion 6: Manhasset, Hempstead, Oyster Bay

These three ports, all located in Nassau County, receive, handle and distribute three major commodities: residual fuel, distillate and gasoline, and construction material (sand, gravel and crushed stone).

Hempstead Harbor, which has a power plant, is the only port that receives and will continue to receive a comparatively large amount (2.7 million barrels in 1971) of residual oil. Thus, it is felt that the present 13-foot channel need only be maintained to allow for barges and small coastal tankers. The small quantity of residual oil destined for Manhasset Harbor could be distributed directly from Hempstead Harbor.

All three ports receive large quantities of distillate and gasoline by coastal tankers and towed tank barges. Based on a correlation with personal income in the area, projections for 1990 receipts have been estimated at over 25 million barrels and changes must be made in present systems to accommodate future flow.

The second major commodity group - sand, gravel and crushed stone - is both produced and consumed in the Sound region and, with the exception of Oyster Bay, is handled by every port. Manhasset Harbor barged out nearly 300,000 tons in 1971, and Hempstead received and shipped almost 3 million tons.

Evaluating the needs of Nassau County as a whole, major consideration was given to the transportation and distribution of clean fuel (distillate and gasoline). The following plans were considered and dropped:

1. Extend the present Northville pipeline, which presently ends at the Nassau-Suffolk County line, to intermediate storage tank farms in the vicinity of the four harbors. This idea was dropped because of the difficulty in obtaining a right-of-way, the high cost, no guaranteed volume, and the competition from vessel transport.
2. Provide a single off-shore mooring facility to receive large tankers, with either a single pipeline to one central storage area or with an individual pipeline to each port. This plan is infeasible because the water area is too shallow, requiring extensive dredging, and heavily trafficked by all types of vessels. A single storage area to provide a 25 million barrel throughput (1990) would cause massive highway congestion due to the large number of tank trucks used to distribute the fuel on land. Conversely, multiple pipelines would be prohibitively costly.
3. Maintain the harbors as is. This would do nothing to alleviate the growing vessel traffic and the possibility of oil spills, with their attendant effects on recreational use of the waters and harbors.
4. Consideration was given to three off-shore facilities - one off-shore of Manhasset Harbor, a second at Hempstead Harbor, and a third within the Oyster Bay area. To minimize distribution congestion, new storage tank farms would be required on Great Neck, Manhasset Neck and in the area of Oyster Bay. While this plan has merit, its obvious high cost, land acquisition difficulties, continued heavy vessel traffic, and the public's strong desire to consolidate petroleum receiving and distribution centers where possible, dictated the need for a compromise solution.

The plan recommended for 1985 in Nassau County consists of the extension of either or both the Oceanside and Plainview pipelines into the area with necessary clean product oil storage facilities. However, if it proves impractical, serious consideration should be given to an off-shore berth facility connected via pipeline to an inland oil storage center on Manhasset Neck. Clean product oil receipts currently received at Hempstead, Manhasset,

and Oyster Bay Harbors would be delivered to the off-shore berths at Port Jefferson and Northville. In this way, these harbors could be left to evolve into prime recreational boating and related activity centers.

7.5 Subregions 7, 8, & 9: Huntington Harbor, Northport Terminal, Port Jefferson Harbor, Northville Terminal, Mattituck Harbor

Looked at as a unit, the three major ports in this subregion - Northport, Port Jefferson and Northville - receive and handle large quantities of petroleum and these quantities are projected to increase. Huntington Harbor commercial waterborne traffic is primarily confined to the receipt of sand and gravel. In 1971, the harbor received for inland consumption over 1/4 million tons.

All the residual oil received at Northport Terminal, a private off-shore platform, and most of that received at Port Jefferson Harbor is consumed by two plants of the Long Island Lighting Company. Plans for increasing the generating capacity at the Northport plant will almost double its oil consumption by 1990, while the consumption at Port Jefferson is projected to remain more stable. None of the 1.2 million barrels of residual at the Northville storage center is consumed on the Island. Most of this fuel is reshipped by barge to the Consolidated Edison Company in New York.

Only Port Jefferson handles both gasoline and distillate fuel, in addition to its large volume of residual. In addition to serving LILCO, the harbor receives and handles clean fuel for Swezy Oil, Exxon, and Mobil, all located on the waterfront, and Consolidated Petroleum, which has a dock at the harbor and tanks three miles inland. There is an extensive handling system both by truck out of the harbor and by pipeline, which extends south to East Setauket and Holtsville and then west to Plainview. At each of these points, distribution is also by truck.

Northville Storage Terminal, while it receives large volumes of residual fuel, is chiefly a distillate handling facility for its Long Island customers. By 2020, it is anticipated that 35 million barrels of distillate will be received and distributed. At present, distribution to the local market area is by truck but with the estimated rise in volume other means will have to be developed.

Looking at the future flow of residual products, it is felt that the facilities for residual fuel are adequate at Port Jefferson, but require considerable expansion at Northport. However, residual storage at Northville could be significantly reduced to provide for future clean product storage and distribution on Long Island.

In the case of Port Jefferson, several plans to ease the receiving load were considered but dropped. An off-shore facility for residual oil is impractical and deepening the present 26-foot channel to accommodate larger residual oil tankers only is not economically justified because of the relatively small quantities involved. Thus it was felt that maintenance of the present channel for residual vessel usage would be the most viable plan.

Because of the expected rise in distillate and gasoline use in this market area, and the recommended shifting of oil receipts from other Long Island northshore ports, it is suggested that an attempt be made to balance their receipt, handling and distribution in Port Jefferson Harbor and Northville Terminal. Although strong institutional constraints are recognized, arranging for each port to receive equal shipments of clean fuel for handling and distribution could be environmentally, economically and socially sound.

To facilitate handling of 24 to 32 million barrels (depending on the need for an off-shore berth at Hempstead) of clean products by 1990 at Port Jefferson, it is recommended that an off-shore facility, submarine pipelines, a new land line, and expansion and modernization of existing storage centers along the pipeline route be provided.

Receipt of another 35 million barrels of clean products by 1990 from Northville Terminal would be greatly aided by a pipeline from its shorefront to about mid-Island and then west to connect with the pipeline from Port Jefferson Harbor. The outcome of this proposal is still unknown due to public opposition to the pipeline itself and to the additional storage tank farms along the pipeline route that would be required for further truck distribution. It is suggested that the relatively small quantity of distillate destined for Huntington Harbor be re-routed via Port Jefferson, thus leaving Huntington Harbor as a sand and gravel and recreational port.

The only other harbor in this market area is Mattituck, which receives supplies for use by Northville Industries. Since the waterway here is shallow, winding and tortuous, it is recommended that all commercial traffic be re-routed to Northville Terminal or Port Jefferson Harbor. This would leave Mattituck free for recreational use alone.

7.6 The Considered Plan's Possible Cost

The scope of this study does not allow for the necessary detailed studies to determine the justification of proposed receiving berths, larger channel dimensions, pipelines, and fuel storage centers. Nevertheless, judgments concerning these critical systems have been made in an effort to establish a magnitude of cost, based on current price levels, for their initial construction. On this basis, an itemized list of planned improvements with possible

costs is presented in Table 7. Noteworthy, costs for required land acquisition, rights-of-way, and various environmental safeguards considered necessary to prevent, contain, or cleanup oil spills are not included. Future LIS studies should also be made to determine whether these increased environmental costs could affect the choice of a location for planned marine transportation facilities.

The requirements for the proposed plan of improvement were based on the present and projected demand for petroleum products and the considered shift or re-routing of these products to key ports on the Sound. See Figure 9, page of this report.

7.7 Long Island Sound Region - Sand, Gravel and Crushed Stone

Study of the present and future needs for sand, gravel and crushed stone had to be based on the conditions in the entire Sound area since LIS is both a producer and consumer of these products. In the past, the north shore of Long Island produced enough sand and gravel to meet most of the needs of the region, but the supplies are being exhausted. Most of the crushed stone is shipped from the New Haven Trap-Rock operation at Pine Orchard, Connecticut, about ten miles east of New Haven Harbor.

According to a U. S. Bureau of Mines estimate, the present reserves of sand and gravel on Long Island will be exhausted in about fourteen years. The less populated counties of Connecticut, such as New London and Middlesex, are said to have considerable reserves of sand and gravel, as well as crushed stone. These factors indicate that a considerable shift in sand, gravel and crushed stone traffic can be expected.

Table 2, page 6, represents a summary of the projected sand, gravel and crushed stone demand of the region based on projections made by the Bureau of Mines in the "Interim Report on Minerals and Mining Resources of the Long Island region, Appendix A, #15.

The waterborne receipts account for approximately 25 percent of the total demand for these commodities in the region. The amount to be received by water-transport is expected to increase slightly past 1985 as the production and shipments of sand and gravel decreases on the north shore of Long Island.

On the mainland side, it is projected that the area east of New Haven will become increasingly important as a sand, gravel and crushed rock producing area. This area is blessed with two rivers, the Thames and the Connecticut, which wind through relatively sparsely populated areas of Connecticut, well suited for the establishment of producing and shipment points.

TABLE 7

<u>A. MAINLAND SIDE</u>		<u>INITIAL FACILITY COSTS</u>		<u>REMARKS</u>	
ITEM		(1,000 \$)		Items No. 1 - 7 are planned for the years 1985 - 1990	
		<u>SUB-REGION THREE</u>			
1.	Fixed offshore pier /W /2 berths for 150,000 DWT tanker (65' depth) 5 miles ± south of New Haven Harbor	\$ 12,000		Includes mechanical and electrical works, log boom, launch and communication facility	
2.	Submarine lines (2) pier to shore 17 miles± of pipe	18,000		Pipe trenching would be required; stand by on shore pump station may be required.	
3.	Land lines (2) New Haven north to Hartford area 104 miles± of pipe	47,000		Includes stand by pump stations; Existing Jet Line phased out	
4.	Inland storage centers for clean products vicinity of New Haven, Meriden and Hartford (8,000,000 bbl)	56,000		Support facilities include: pump stations, storage center pipeline, dikes and roads, access roads, pollution and fire protection system, maintenance and communication facilities, etc.	
5.	Deepen New Haven Harbor access channel to 40' at mean low water	30,000		Disposal of dredged materials in Sound and possible modification of certain inshore berths and wharves	
6.	Land line hot residual oil, 32 miles± of pipe, New Haven to Middle Town	13,000		Insulated pipeline-heat and pump stations may be required along line	
7.	Expansion and modernization of existing storage centers for residual oil at New Haven and Middletown	12,000		Support facilities required similar to those listed in item 4 above in addition, heat units will be required	

TABLE 7 (cont'd)

SUB-REGION FOUR

Items No. 8 - 13 below are planned for the years 1985 - 1995

8. Fixed offshore pier (similar to item 1 above) miles SSW of Bridgeport Harbor	12,000	
9. Submarine lines (2) pier to shore 28 miles of pipe	30,000	Stand by on shore pump stations may be required; pipe trenching would be required
10. Land line for residual oil, 4 miles of pipe Bridgeport to Devon	2,000	Insulated pipeline
11. Expansion and modernization of existing storage centers for residual oil (300,000 bbl) at Devon	2,000	Similar facility components as in item 7 but significantly smaller center

SUB-REGION FIVE AND SIX

12. Land lines (2) Bridgeport to East Chester Creek area, 91 miles of pipe	41,000	Includes stand by pump stations along line
13. Inland storage centers for clean products from Bridgeport to East-Chester Creek area, 2,900,000 bbl	21,000	Support facilities similar to those listed in item 4 above
Total Mainland Side	\$290,000	

TABLE 7 (cont'd)

SUB-REGION SIXItems No. 14-23 below are planned for the years 1980 - 1990
Stand by pump station on line may be required

14. Land lines (2) 16 miles of pipe in Nassau County	7,000	Required support facilities similar to item 4 above
15. Inland storage center for clean products in Nassau County (1,800,000 bbl)	13,000	

SUB-REGION SEVEN

Required support facilities similar to item 4 and 7 above

16. Expansion and modernization of existing storage center for residual oil at Northport (1,000,000 bbl)	8,000	
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TABLE 7 (cont'd)

SUB-REGION SEVEN AND EIGHT

17. Land line Plainview to Port Jefferson, 28 miles ⁺ of pipe	13,000	Stand by pump station may be required
18. Expansion and modernization of existing storage centers for clean products (1,800,000 bbl) Plainview to Port Jefferson	11,000	Required support facilities similar to item 4

SUB-REGION EIGHT

19. Submarine lines (2) shore at Port Jefferson to offshore pier, 6 miles ⁺ of pipe	6,000	Pipe trenching would be required
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20. Fixed offshore pier (similar to item 1) 1 mile ⁺ NE of Port Jefferson	12,000	
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SUB-REGION EIGHT AND NINE

21. Land lines (2) Northville to Holts- ville 56 miles ⁺ of pipe	25,000	Includes stand by pump station
22. Inland storage centers for clean products from Northville to Holts- ville (3,200,000 bbl)	22,000	Support facilities similar to item 4

SUB-REGION NINE

23. Expansion & modernization of existing fixed offshore facility	1,000	
Total Long Island Side	\$118,000	
Grand Total	\$414,000	

The projected sand, gravel and crushed rock traffic for the mainland ports is based on the premise that the traffic at the ports serving the densely populated counties of Westchester and Fairfield will stabilize as road and other commercial construction in these areas reaches a saturation point. Considerable growth in construction activities, however, can still be expected in the area served by ports east of Norwalk.

The projected distribution of sand, gravel and crushed rock traffic at the Long Island ports is based on the assumption that by 1985 all the remaining production of sand and gravel will be for local consumption. Therefore, after 1985, the ports of Manhasset, Hempstead, and Port Jefferson will become primarily receiving ports for sand, gravel and crushed rock. Again, as in the case of the mainland ports, the greatest growth of sand and gravel traffic can be expected at the ports on the eastern part of Long Island's north shore.

The demand for sand, gravel and crushed rock in the region will continue to increase and according to the U. S. Bureau of Mines, this increase will take place at the growth rate projected for the population growth of the region. Since low-cost transportation is a very critical factor in the delivered cost of these commodities, it is essential that sufficient low-cost water transport capacity be provided.

Most of the present sand, gravel and crushed rock shipping and receiving facilities are located at the very small ports, most of which are limited to ten feet of water. This essentially limits the basic water transport unit to the 1,000-ton barge. As with most other bulk commodities, the shipment of sand, gravel and crushed stone is most efficiently accomplished by shipments in the largest lot size possible. This is presently accomplished by making a barge train consisting of six to twelve barges. The size of the barge train is limited to what can safely be maneuvered through the confined areas of Hellgate at the west end of the Sound in the port of New York, and the shallow water areas of the ports where most of the sand and gravel facilities are located.

The loading and discharging of the sand and gravel barges is presently accomplished by means of mobile crawler-type cranes fitted with clam shell buckets, although at some high volume operations the loading is done using conveyor belts and chutes.

The New Haven Trap-Rock operation at Pine Orchard, which has been in operation since 1967 - 1968, is an excellent example of present sand and gravel production and shipping technology. It is essential that the producing area be very close to a mode of low-cost transportation. This would

dictate that the sand and gravel quarries be at the water's edge, as is presently the case at Hempstead, Manhasset and some other north shore Long Island facilities. There is, however, a tremendous competition for the use of waterfront land for residential, recreational and wildlife preserve use. New Haven Trap-Rock has solved this problem by locating its quarries several miles inland from the water and transporting the crushed rock to the loading facility at Pine Orchard by means of its own railway. This considerably lessens the waterfront land requirements for sand and gravel operation, as well as socio-political pressures from residents and environmentalists.

Since the large lot sizes are available in sand and gravel shipments, it is suggested that barge train sizes be maximized with possible experimentation with Mississippi-type push boats which may eliminate the requirements for the time-consuming tow line shortening process presently required as the barge trains enter the port of New York area.⁽¹⁾

(1) The above information regarding sand, gravel and crushed rock was taken from the report, "The Future Water Transportation System Requirements for Long Island Sound", John J. McMullen Associates, Inc., N. Y., 24 October 1973.

8.0 EVALUATION OF ALTERNATIVE PLANS

In formulating and evaluating alternative plans for particular ports, it became apparent that receiving, handling and distribution systems had to be considered simultaneously, for it is their combined efficiency which dictates the economic feasibility of each component. In fact, part of the reason the major oil companies are integrated vertically is to control these interdependent system components. Tentative 1990 NED-EQ recommendations are summarized by subregion in Table 8.

Realizing, then, that the alternatives for receiving could not be evaluated separately from those for handling and distribution, and vice versa, the study findings indicate that the best way to bring petroleum into the region and to its markets in the future would be through consolidation of ports into a few key receiving points with pipelines used to distribute the products to the major consumption centers. These new major ports could be improved either by building an off-shore berth, dredging to deepen channels, or both. The off-shore berth is generally preferred because it could accommodate larger vessels than could the harbors, thus reducing vessel trips and the opportunities for spills; it would greatly reduce dredging and spoil disposal requirements; it would probably provide cost savings to the consumer; it would free the inner harbors for recreational boating and other uses; and it would facilitate the relocation of storage tanks off the waterfront.

Off-shore berths do have limitations, however. About thirty days a year, on the average, weather conditions make offloading on the Sound unsafe. Also, residual oil can only be pumped 1 - 2 miles from off-shore without solidifying. Therefore, in Connecticut, where the distance from ports to deep water is 3 - 5 miles, residual oil would still have to be brought into the harbors by tanker. On Long Island, the Northport power plant presently uses off-shore unloading. At Port Jefferson, the distance would be about 2-1/2 miles. Feasibility there is questionable, but it would be up to the power company to make a final assessment of both technical and economic feasibility.

While much more detailed study is required, technologies are now available that provide for construction of off-shore berths to accommodate oil product carriers and the movement of oil through pipelines. The type of construction is a factor of prevailing site conditions, including weather, wind velocity, fetch, duration tides, currents and bottom hydrography. The flexibility presented by an off-shore berth provides for the relocation of areas for onshore facilities that are technically and ecologically feasible. Furthermore, a study of the operating characteristics of the off-shore

TABLE 8
SELECTED SYSTEM ALTERNATIVES LEADING TO
TENTATIVE NED-EQ RECOMMENDATIONS

SUB REGION	PLAN (1990)	SYSTEMS		
		RECEIVING	HANDLING	DISTRIBUTION
One	NED	Maintain 36-foot access channel		Truck
	NED	Enlarge maneuvering area opposite state pier to a depth of 32 ft		Truck
	EQ		Expansion-Modernization of existing facilities	
Two	EQ-NED	Re-route residual oil from Conn. River destined for Middletown and Hartford via New Haven Harbor	Expansion-Modernization of existing facilities	Truck
	EQ-NED	Re-route distillate and gasoline fuels from the Conn. River destined for Middletown Hartford and other inland community areas via deep water berth offshore of New Haven	Consolidation of existing storage (see sub-region 3)	-
Three	NED	Deepen access channel to 40 feet		Truck
	EQ-NED	Offshore berth with submarine clean products pipeline to New Haven area then Northerly to Hartford area	New inland storage centers in general area of New Haven Meriden and Hartford total storage capacity and acreage required, 8MB - 58 acres	-
	EQ-NED	Hot Oil pipeline from New Haven area northeasterly to Middletown	New heat station at New Haven. Expansion-modernization of existing facilities at New Haven and Middletown. Total storage capacity and acreage required, 3.5 MB-24 acres	
Four, Five and Six (Mainland)	EQ-NED	Maintain 45-foot channel	Expansion-Modernization of existing facilities. Residual storage capacity and acreage required, at Bridgeport 0.9 MB-6 acres	Truck
	EQ	Re-route residual oil transshipments from New Haven Harbor destined for Devon Power Plant on the Housatonic River via hot pipeline from Bridgeport Harbor to Devon.	Expansion-Modernization of existing facilities storage and acreage requirements at Devon 0.5 MB-25 acres	-
	NED-EQ	Maintain existing channel and maneuvering area depths at Bridgeport Norwalk, Stamford Port Chester and Eastchester Harbors as needed	Expansion & Modernization of existing residual & dry bulk facilities. Phase out existing clean product shorefront facilities	Truck
	EQ-NED	Offshore berth possibly opposite Southport with submarine clean products pipelines to Bridgeport, 1995	Expansion & Modernization of existing facilities near Johnson Creek	Truck
	EQ-NED	From offshore berth extend clean product pipelines to Southport area and westerly to Eastchester Creek area	Build new inland storage centers along pipeline route. Storage capacity and acreage required 2.9 MB-24 acres	Truck
Six and Seven (Long Island)	EQ	Re-route refined petroleum products destined for Manhasset Harbor via offshore berth opposite Northville	Phase out existing onshore petroleum facilities at Manhasset Bay Harbor	
	NED-EQ	Pipeline extension into mid-Nassau County	Inland fuel storage center in Nassau County for clean products storage capacity and acreage required 1.8 MB-12 acres	Truck
	NED	Maintain Manhasset and Hempstead Harbor channels	Expansion & Modernization of existing shorefront facilities as needed	Truck

Eight & Nine	EQ	Re-route refined petroleum products destined for Oyster Bay and Huntington Harbors via offshore berths at Port Jefferson and Northville	Phase out existing petroleum facilities at Oyster Bay and Huntington Harbors	-
	NED-EQ	Maintain existing offshore berth opposite Northport	Expansion & Modernization of existing shorefront facilities. Storage capacity and acreage required: 1.8 MB-12 acres	-
	NED	Maintain 26' access channel	Maintain existing residual fuel storage facilities	-
	EQ-NED	Offshore berth opposite port Jefferson with submarine pipeline to shore	Expansion & Modernization of Inland Fuel storage center along pipeline route for clean products. Storage capacity and acreage required: 3.2 MB-20 acres	Truck
	EQ	Maintain existing offshore berth with submarine pipeline to shore	Maintain existing on shore facilities	Truck
	EQ-NED	Additional clean product pipeline from offshore berth to inland storage center at Holtsville	New Inland clean products storage centers along pipeline route. Storage capacity and acreage required: 3.2 MB-20 acres	Truck
	EQ		Residual oil receipts and storage practice be phased down	-
<hr/>				
One-Ten	EQ-NED	Detailed study be made to determine future specific sand, gravel, and crushed stone source locations and specific product destinations in LIS Region. In addition determine specific LIS ports worthy of development for the receipt and distribution of these dry bulk products to consumers.		

complex is necessary to determine the choices of design, layout and construction. Other functional and operating requirements affect the design decisions concerning the off-shore berth, the supporting pipeline and the required on-land fuel storage center. Several types of off-shore oil receiving systems in world-wide use today are described in Appendix B of this report.

Even with the development of off-shore berths, some dredging would continue to maintain channels for dry cargo vessels, residual oil carriers and other commercial and recreational craft.

The economic feasibility of pipelines varies according to product moved. The "clean" products line carries all petroelum products except residual oil. Residual is transported in "hot lines", so named because the oil must be heated to well over 100° F in order to flow easily. Several heating stations would be required along the proposed route to assure continued flow. Where rights-of-way already exist, pipelines can have minimal adverse impacts upon people and resources. They certainly are far better for traffic congestion, air quality, reliability, and energy conservation than truck distribution. Pipelines moving high volumes are also generally more economical than trucks. The real test of their economic feasibility, however, is when compared to barge costs where barges are an alternative. For example, residual oil is barged presently from Groton to Middletown and Hartford and from Bridgeport to Devon on the Housatonic River. Gasoline and distillate oil are also barged up the Connecticut River to Hartford, but originating in New Haven for the most part. If all of this barging were replaced by pipelines, it would be possible to limit channel deepening in New London, Bridgeport and the Connecticut River, and most maintenance dredging on the Connecticut. When these dredging costs foregone are counted in, the pipelines become very attractive economically, as well as socially and environmentally. Dredging cost estimate with and without the considered plan for the period 1964 - 1993 is presented in Table 9. Before any additional pipelines are built, however, a much more detailed analysis of the ultimate cost of the entire plan would be required.

TABLE 9 PROJECTED FEDERAL MAINTENANCE AND
IMPROVEMENT DREDGING COSTS FOR LIS PORTS

Period	<u>Without Plan</u>		<u>With Plan</u>		<u>Difference with & without</u>	
	<u>Volume^a</u>	<u>Cost^b</u>	<u>Volume^a</u>	<u>Cost^b</u>	<u>Volume^a</u>	<u>Cost^b</u>
'64-'73	2,400,000	9,600,000				
'74-'83	6,000,000	30,000,000	3,600,000	18,000,000	(2,400,000)	(12,000,000)
'84-'93	9,500,000	47,500,000	5,000,000	25,000,000	(4,500,000)	(22,500,000)
Total						
'74-'93	15,500,000	77,500,000	8,600,000	43,000,000	(6,900,000)	(34,500,000)

a Volumes expressed in cubic yards

b Cost computed at \$4/cubic yard through 1973 and \$5/cubic yard '74-'93

Except for residual oil consumed in the port, there is no justification for oil storage tanks preempting other water-related land uses from prime waterfront locations. Storage should be located near major consumption centers with good highway access. Traffic through local streets should be minimized.

Relocating existing shorefront tanks inland can be phased over a period of ten - twenty years as tanks have to be replaced, waterfront property taxes increase, and alternative tax producing water-related developments are proposed. Since tank farms provide less tax per acre than virtually any other industrial use, it should be possible for each city to maintain or increase its tax base through intensive development of only a portion of the relocated tank farm acreage, with the balance left for recreation, public access to the water and other public uses.

For cross-Sound travel there is a growing need for a year-round, reliable and rapid ferry service to cut travel time and reduce traffic on the two existing East River Bridge crossings and the highways which feed them. Although most people take a ferry to save time, it also provides recreation and relaxation, and saves on fuel consumption.

Feasible improvements to existing service routes are quite limited. The Bridgeport-Port Jefferson ferry, even if it had new and larger vessels, is limited by local traffic problems through the old village center of Port Jefferson. Expansion would probably be opposed by that community. For the East End crossing, New London-Orient Point, secondary roads the length of the North Fork discourage truckers and other travelers bound for and coming from western Long Island.

The present fleet of Long Island Sound ferries includes merely one 39-vehicle vessel (Bridgeport-Port Jefferson) and three 25-vehicle vessels (New London-Orient Point). This is in sharp contrast to experience elsewhere in the world where giant ferries operate across many bays, sounds and fjords. In Puget Sound, Washington, for example, a total of eighteen vessels are in service, including two jumbo ferries which carry 206 vehicles and up to 2,000 passengers.

A mid-Sound crossing, if connected to a limited access highway on Long Island, would offer several advantages to the two existing ferry services. It would provide the greatest time saving to the largest number of people. This would reduce transportation costs for many goods. It would open all New England through Interstate 91 and 95 for Long Islanders, while providing access to Atlantic beaches, including Fire Island National Seashore, for New Englanders. It would keep traffic away from the North Fork, which we hope will be preserved much as it is today. Finally, the ferry would not be a generator of traffic and development the way a bridge might be. Since the crossing time for the ferry is likely to be on the order of an hour and a half, it would not be very useful for commuting.

9.0 WORK GROUP RECOMMENDATIONS

The recommended plan will require active and continued public and private support for its implementation. The magnitude of cost for the plan has been tentatively set at \$414 million. Improvements to the navigation receiving system must be made in concern with handling and distribution system improvements. After the year 1990, it is unclear whether supply and consumption will continue to increase, rapidly fall, or simply level off. For planning purposes, the plan is aimed at the 1980 to 1995 time frame. Coastal resource planning for needed nearshore or offshore product receiving facilities should be the dual responsibility of the States and the Federal government. A summary of yesterday's and tomorrow's planned petroleum product flow with tentative recommendations is presented in Table 10.

Recommended actions are listed below:

1. New York and Connecticut should each establish a new quasi-public corporation with the responsibility to approve offshore oil receiving berths and related pipelines, and site new fuel storage centers. It would have bonding and condemnation powers, and lease these facilities to petroleum distributors.

2. Consolidate ports. To reduce vessel trips, oil spillage, dredging, highway congestion around the ports, shorefront land consumption by storage tanks and fuel cost to consumers, petroleum receipts should be concentrated in five ports: New London, New Haven, Bridgeport, Port Jefferson and Northville. The other minor ports may continue to receive some residual oil, sand and gravel, stone, and other bulk cargoes, but gasoline and distillate oil receipts should be phased out by 1995. To accomplish these goals, the following actions are recommended:

- a. Offshore berths. The new quasi-public corporation should develop offshore receiving terminals at New Haven (1990), Port Jefferson (1985), and Bridgeport (1995) with submarine pipeline connected to inland fuel storage centers.

- b. Pipelines. Full use should be made of existing pipelines from New Haven to Chicopee, Massachusetts and Port Jefferson to Holtsville on Long Island. The new quasi-public corporation should also build new "clean" product lines connecting Northville to Holtsville by 1980; Plainview to Nassau County by 1985; and New Haven to Hartford by 1990; and from Bridgeport to the Bronx by 1995. "Hot lines" should also be built from Bridgeport to Devon and New Haven to Middletown, both by 1985.

- c. Deepen channels. The only harbor likely to need deepening for commercial shipping if the recommended changes in the receiving system are made is New Haven, where 80 percent or about 60,000,000 barrels of

Connecticut's residual oil is expected to be received. It should be deepened to 40 feet by 1985. Channel deepening in the other harbors would only be justified if bulk cargo traffic increases substantially.

The result of this port consolidation should be faster, cleaner, safer, and cheaper distribution of goods in the region. Petroleum vessel movements into and out of ports on the mainland side from the Housatonic River to East Chester Creek, except to oil-burning power plants would be phased out. Petroleum traffic on the Connecticut River would be similarly phased out. The plan would also reduce Federal channel dredging requirements by about seven million cubic yards for a savings of about \$35 million to the taxpayer over the next twenty years. (See Table 9 for further details.)

3. Tank farm relocation inland. The quasi-public corporations should develop new oil tank farm sites which satisfy all environmental regulations and recommended design criteria (see P-3 Shoreline Appearance and Design Planning Report) to encourage relocation of existing waterfront storage tanks and provide sites for needed expansion. New York and Connecticut should work with the municipalities to develop economic incentives to encourage the relocation as well as acceptable types of redevelopment.

4. Ferry service. New York and Connecticut should encourage the immediate development of high-speed, year-round ferry service between New Haven, Connecticut and Shoreham/Wading River, New York. Improvements on other routes should be left to private sector initiative.

Much more detailed study is needed to confirm the above recommendations. Major questions need resolution, such as which ports should be prepared to receive, handle, and distribute each type of traffic, including bulk cargo and general cargo. Also, the combination of investments, Federal and non-Federal, will have to be determined to bring about an efficient receiving, handling, and distribution system that best serves our present and future social and economic environment.

The Long Island Sound Study on Marine Transportation, Ports and Harbors recognized and dealt in a surface way with some of these important problems. However, the above issues and problems could be better answered effectively with the help of a detailed regional harbor and port survey. Thus, it is recommended that the detailed planning of the nearshore and offshore facilities for future navigation be accomplished by the United States Army Corps of Engineers, and the States of New York and Connecticut. New Federal Study authorities are recommended as follows:

Comprehensive studies of harbor-port requirements. One regional study for the Connecticut mainland ports; a separate but less complex study for

the Long Island ports. Comprehensive survey and review of previous reports need to be conducted to determine the optimum number and spacing of ports to service the mainland's regional market area, and the harbor and specialized terminal facilities required at various ports. The surveys cannot be confined to harbor or port development only, they must involve undertaking detailed analyses of trends in industrial growth and location; commodity movements and fleet composition; identification of implications, by region, of projected economic activity, traffic movement and vessel size; analysis of port cargo handling and associated facilities; plus evaluation and recommendations for financial participation by State, local political entities, and commercial and industrial interests.

In view of the above marine related receiving, handling, and distribution system problems and needed solutions, studies should also explore fully all feasible technological alternatives to traditional harbor deepening; such as installation of offshore transfer facilities. The study's initial step would involve preparation of industrial, economic and commodity forecasts as a basis for defining study regions. It is felt that, where feasible, studies be separated by major commodity received at ports; i.e., (1) residual oil, (2) clean oil products (distillate, gasoline, jet fuel, asphalt, and kerosene), (3) other bulk cargoes (sand, gravel, crushed stone, chemicals, scrap metals, etc.), (4) general cargo including containerized commodities. To complete the study picture, people movements on the Sound primarily via vessel be understood and include the competitive relationship of bridge and air transportation in an effort to formulate a plan of improvement.

Additionally, the Corps of Engineers should begin feasibility studies on the use of solid waste and dredge spoils to build artificial islands. (See the Study's main report. People and the Sound).

10.0 FINAL RECOMMENDATIONS

The preceding recommendations have not necessarily been approved by the New England River Basins Commission. At the time of this report's publication, the draft main report of the Long Island Sound Regional Study is undergoing public review and comment for consideration in the final document. The FINAL RECOMMENDATIONS on Marine Transportation are therefore to be found only in the final version of the Study's main report - to be published in the spring of 1975.

TABLE 10 - SUMMARY OF YESTERDAY'S AND TOMORROW'S PLANNED PETROLEUM PRODUCT FLOW ON LONG ISLAND SOUND WITH TENTATIVE RECOMMENDATIONS

Port/ Product	1971 Receipts ^a	1971 Storage ^b	1990 Receipts ^a	Additional Storage Needed ^b	Recommended Program
NEW LONDON					
Distillate	1.2	3	2.3	0	Maintain 36' channel, eliminate oil barge transshipment operations at New London destined for Connecticut River terminals by 1990.
Residual	2.3	13	3.6	0	
Total	3.5	16	5.9	0	
THAMES RIVER					
Distillate	1.1	1	2.3	0	Maintain channel to meet future vessel traffic needs.
Gasoline	0.5	0.3	1.0	0.2	
Residual	3.4	c	3.6	c	
Total	5.0	1.3	6.8	0.2	
CONNECTICUT RIVER					
Distillate	5.0	3	9.1*	0	Phase out oil barge traffic by 1990; replace by use of existing "clean" line, New Haven to Hartford to Springfield, and new "hot oil line", New Haven to Middletown.
Gasoline	8.5	4	17.2*	0	
Residual	8.6	5	17.7*	0	
Total	22.1	12			
NEW HAVEN					
Distillate	17.7	10	41.3	28 ^d	Deepen access channel to 40 feet and build hot oil pipeline by 1985. Build offshore berth and clean product pipelines to New Haven and north to Hartford area by 1990. Build new inland storage centers for clean products along pipeline Route by 1990.
Gasoline	16.3	13	50.6	17 ^d	
Residual	14.0	12	43.8	12 ^e	
Total	48.0	35	135.7		
HOUSATONIC RIVER					
Distillate	0	0			Receive residual via "hot line" from Bridgeport to Devon by 1985.
Residual	2.3	0.5	4.7 ^j	1.9	
Total	2.3	0.5			
BRIDGEPORT					
Distillate	3.1	3	20.8	3	By 1995 build offshore berth, clean product pipelines via berth to Bridgeport to Bronx and expand Johnson's Creek oil storage facilities; build hot oil pipeline Bridgeport to Devon by 1985; Maintain 35-foot access channel.
Gasoline	3.5	2	28.1	4	
Residual	9.9	6	15.7	0	
Total	16.5	11	64.6	7	
NORWALK					
Distillate	1.2	0.6	2.2 ^j	1.4	Receive distillate and gasoline via Bridgeport-Bronx pipeline by 1995; new inland tank farms along pipeline route, maintain 12' channel.
Gasoline	0.1	0	0.2 ^j	0.6	
Residual	0.6	0.4	0.9	0	
Total	1.9	1.0		2.0	
STAMFORD					
Distillate	3.2	4	5.8 ^j	1.0	Receive distillate and gasoline via Bridgeport-Bronx pipeline by 1995; new inland tank farms along pipeline route, maintain 15' channel.
Gasoline	0.9	0.5	1.7 ^j	0.3	
Residual	0.5	0.2	0.0	2.8	
Total	4.6	4.7		4.1	

See footnotes on second page.

*Amounts are included in New Haven Harbor 1990 receipts

a Receipts expressed as million barrels.

b Storage expressed in acres.

c Storage provided at Groton for Thames River market area.

d Additional and existing storage should all be at inland storage centers - in general area of New Haven, Meriden, and Hartford.

TABLE 10- SUMMARY OF YESTERDAY'S AND TOMORROW'S PLANNED PETROLEUM PRODUCT FLOW ON LONG ISLAND SOUND WITH TENTATIVE RECOMMENDATIONS (continued)

Port/ Product	1971 Receipts ^a	1971 Storage ^b	1990 Receipts ^a	Additional Storage Needed ^b	Recommended Program	
PORT CHESTER						
Residual	0.2	0	0		Products received via Bridgeport-Bronx pipeline by 1995	
Distillate	1.1	0.7	2.0 ^j	1.0		
Gasoline	0.6	0	1.1 ^j	0.7		
Total	1.9	0.7		1.7		
EASTCHESTER CR.						
Residual	0.4	0	0.7		Clean products received via Bridgeport-Bronx pipeline by 1995. storage provided along pipeline route.	
Distillate	2.9	2	5.2 ^j	3		
Gasoline	8.5	4	12.4 ^j	6		
Total	11.8	6		9		
MANHASSET BAY						
Residual	0.01	0	0	0	Shift receiving to offshore berths opposite Port Jefferson and Northville by 1985.	
Distillate	2.9	3	5.0 ^h	0		
Gasoline	1.0	1	2.1 ^h	0		
Total	4.0	4				
HEMPSTEAD HARBOR						
Distillate	2.0	1	3.6 ^h	3	Shift receiving of clean products to Port Jefferson and Northville offshore berths by 1985. maintain channels for residual oil and other product traffic. Build clean product pipelines, Plainview to mid-Nassau County & construct new storage facilities along pipeline Route and at terminus by 1985.	
Gasoline	4.9	4	9.3 ^h	3		
Residual	2.7	1	2.4	0		
Total	9.6	5		6		
OYSTER BAY (9)						
Residual	0.05	-	0	0	Shift receiving to Port Jefferson and Northville by 1985. Locate all storage tanks along pipeline route.	
Distillate	2.0	1	4.6 ^h	0		
Gasoline	1.0	0.5	2.0 ^h	0		
Total	3.3	1.5				
NORTHPORT						
Residual	8.4	10	21.9	0	Expansion and modernization of existing facilities by 1990	
PORT JEFFERSON						
Distillate	8.9	7	24.8	9		Develop offshore berth by 1985 maintain 26' channel, locate all storage, except residual, inland along pipeline route. Build new clean line, from berth to Port Jefferson to Plainview.
Gasoline	6.6	4	7.8	1		
Residual	6.7	4	7.2	0		
Total	22.2	15	39.8	10		
NORTHVILLE						
Distillate	5.3	5	16.2	10	Complete pipeline, Northville-Holtsville by 1980 new storage along pipeline route. Residual oil storage phased down; maintain existing offshore facility.	
Gasoline	0	0	19.2	10		
Residual	15.4	11		-		
Total		16	35.4			

e Storage areas at Bridgeport, Devon, New Haven, Middletown, and Hartford.

g Oyster Bay figures include Huntington Harbor totals.

h 1990 clean product flow has been rerouted and balanced between Port Jefferson and Northville ports.

j Amounts are included in Bridgeport 1990 receipts.

APPENDIX A

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APPENDIX B

Glossary

"CLEAN" FUELS	gasoline and distillate oil.
DISTILLATE OIL	fuel used for general heating.
"HOT LINE"	insulated pipeline required for residual oil, which must be heated in order to flow.
LIGHTERING	removing some oil from large tankers to smaller vessels or barges outside of port. This is done when a port's channel is too shallow to allow the tankers to enter with a full load.
OFF-SHORE BERTH or FACILITY	terminal or island constructed in deep water to allow large tankers to discharge their cargo without coming in- to port.
RESIDUAL OIL	fuel used for electric generating plants and industrial heating.
TANK FARM	the oil storage tanks, other facilities, buffer zones, pipelines and roadways that make up an inland fuel storage area.
OIL THROUGHPUT	The ratio of product moved to product stored. Industry claims the following ratios are required to insure a reasonably sound business operation: For example, residual 13 to 1; gasoline 12 to 1; and distillate 10 to 1.
OIL STORAGE CAPACITY in ACRES	150,000 bbls per acre (estimated)
INLAND STORAGE CENTRAL AREAS	Facilities are hard to place, for this reason, no specific locations are given. Site selection and design criteria to be developed in later de- tailed studies.
DWT	dead weight tonnage. (The cargo carrying capacity of a ship.)

APPENDIX C

Offshore Oil Receiving Systems

Offshore facilities for discharging petroleum would greatly reduce or eliminate the economic cost and environmental effect of dredging. They also offer a great degree of flexibility in the location of new ports, as well as the location of inland storage facilities crucial to a regional marine transportation plan for LIS. The technical aspects of constructing deepwater offshore discharge facilities are entirely feasible. The knowhow for constructing these terminals has been developed over the past 10 to 15 years. The technical advances made in this field have allowed for the construction of an increasing number of terminals capable of handling tankers having tonnages of several hundred thousand deadweight tons. Worldwide, there are numerous offshore facilities and in the coming years an even greater number will be built in view of the economic and environmental advantages offered by them.

Of the several types of offshore oil receiving systems in worldwide use today, one or more may be applicable to serve the LIS area contingent upon the technical, environmental, institutional, and social considerations of the particular site. These various systems are described below.

Conventional Buoy Mooring System - The conventional buoy mooring system (Figure 3) uses a number of buoys to maintain a tanker in a desired position and orientation. Products are transferred to land-based storage areas through submerged pipelines. Many of these facilities have been in operation for several years, but such structures have limitations. Because tankers must be moored in a fixed position, the system is limited to sites where prevailing winds are longitudinal to the berth. This type of installation is not suitable for sites having strong broadside winds and rapid currents. In addition, 100,000 dwt appears to be the maximum size of vessel suitable for this system.

Single-Point Buoy Mooring System - With the single-point buoy mooring system (Figure 4) the tanker is moored directly to a very large buoy which is held in position in deep water by multiple anchors and chains. This buoy has a central piping manifold connected by flexible hoses to an underwater piping system for transferring products to storage areas. Floating flexible hoses connect from the buoy to the tanker discharge manifold. This system permits the tanker to berth with the bow headed into the direction of the prevailing winds and to move with changes in wind and/or current direction while at berth. Single-point moorings are suitable for operation at offshore locations that are subject to severe sea and weather conditions. Continuous technical improvements to this system are minimizing the down time due to such conditions.

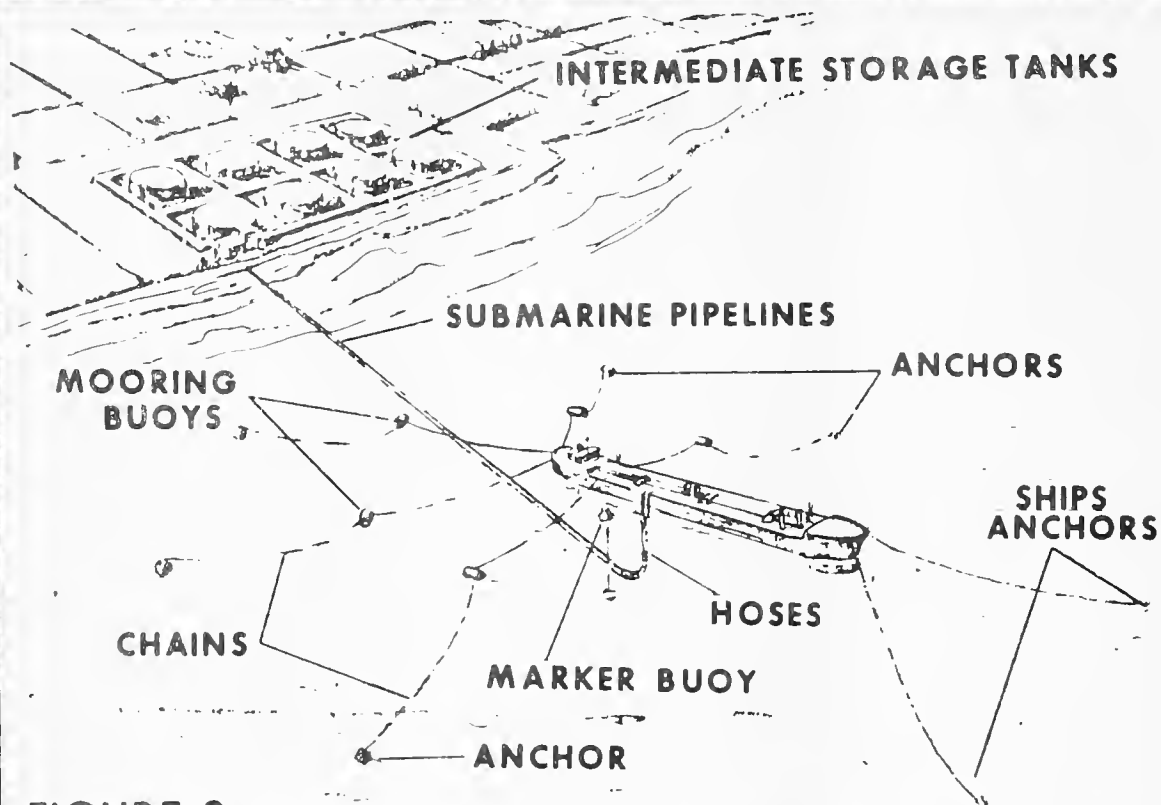


FIGURE 3

CONVENTIONAL BUOY MOORING SYSTEM

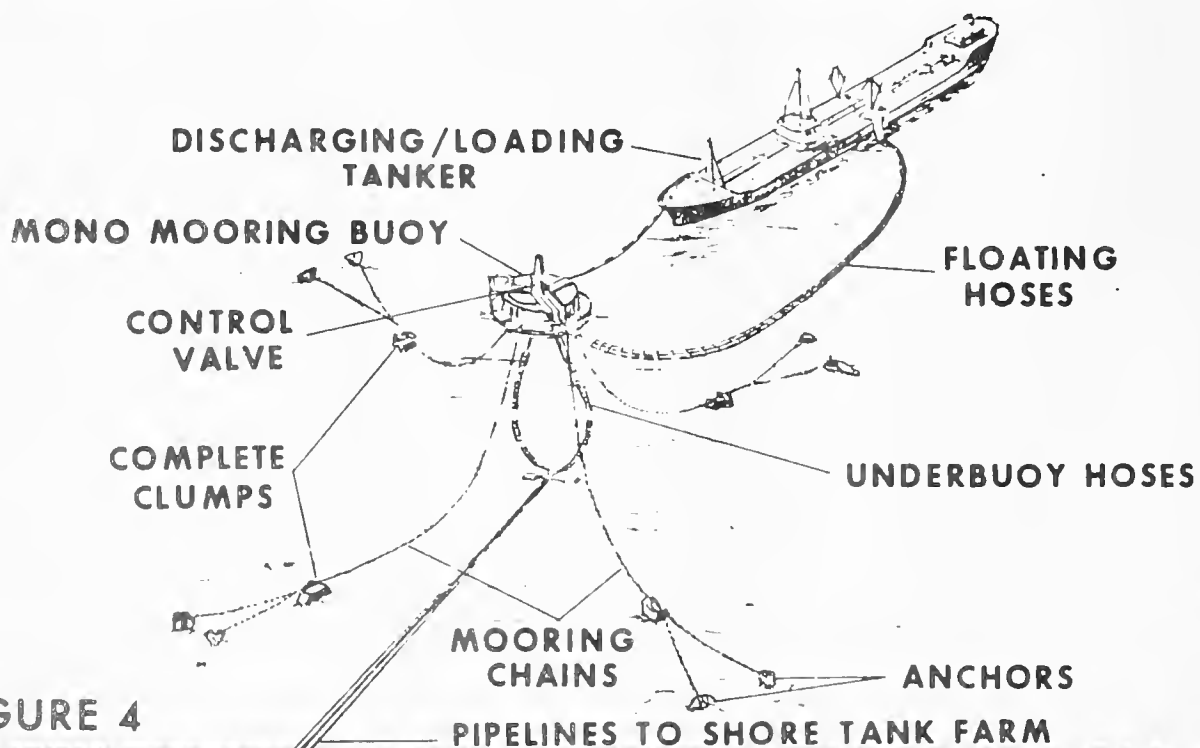


FIGURE 4

SINGLE POINT MOORING BUOY SYSTEM

There are two basic drawbacks to single-point moorings. First, mooring operations generally require the use of a launch. Seas in excess of six to eight feet adversely affect the launch operations and berthing of the tanker may not be possible. Secondly, there is a tendency of tankers to creep towards the buoy during calm weather and slack tides. This can lead to possible fouling of the buoy mooring chains or submarine hoses. Floating hoses are also susceptible to vessel damage and to wave damage in heavy seas. Jamming of the buoy turntable and subsequent wrapping of hoses around the buoy can also cause damage.

Single Anchor Leg Mooring System - The single anchor leg mooring system (Figure 5) is a modification of the single-point mooring system in that it eliminates the problems associated with floating and underbuoy hoses, and damages to the swivel mechanism. In this system, the hose and swivel mechanism is located on the sea floor. The buoy floats on the water and is anchored to the bottom by a single chain, allowing the buoy to be pushed aside and submerged without damage should it be struck by the vessel while berthing or while drifting at berth. Thus, the swivel mechanism and submerged hose connection are well protected. The single anchor leg mooring can be designed to function properly in deep water and is capable of serving tankers exceeding 500,000 dwt.

Single-Point Mooring Pier - A single-point mooring pier (Figure 6) consists of a pylon or tower fixed to the sea floor and a long swivel-mounted, semi-submersible floating arm, with a floating tower at its end. The tanker moors at the bow, permitting it to feather into the wind and/or current so that the tanker can assume a line of least resistance. The oil moves from the vessel's manifold through a short hose to the floating structure and then into submarine pipelines. The floating arm is less vulnerable to sea conditions than a monobuoy. The main advantage over single-point moorings and monobuoys is that the flexible hose elements are replaced by a rigid truss structure. The main disadvantage is that single-point moorings usually cost two to five times more than monobuoys.

Marginal Piers - Marginal piers (Figure 7) are fixed structures placed close to an existing shore or island, with oil being carried ashore by a trestle-supported pipeline. A tanker is moored with the aid of tugs for safe berthing. Heavy seas are a major factor affecting berthing operations and consideration is given to the provision of a sheltering breakwater to permit the facility to be used under more adverse conditions. The number of vessels berthed concurrently is governed by the length of the pier.

Sea Islands - Sea islands are similar to marginal piers except a submarine pipeline system is used to transport the oil from the vessel to

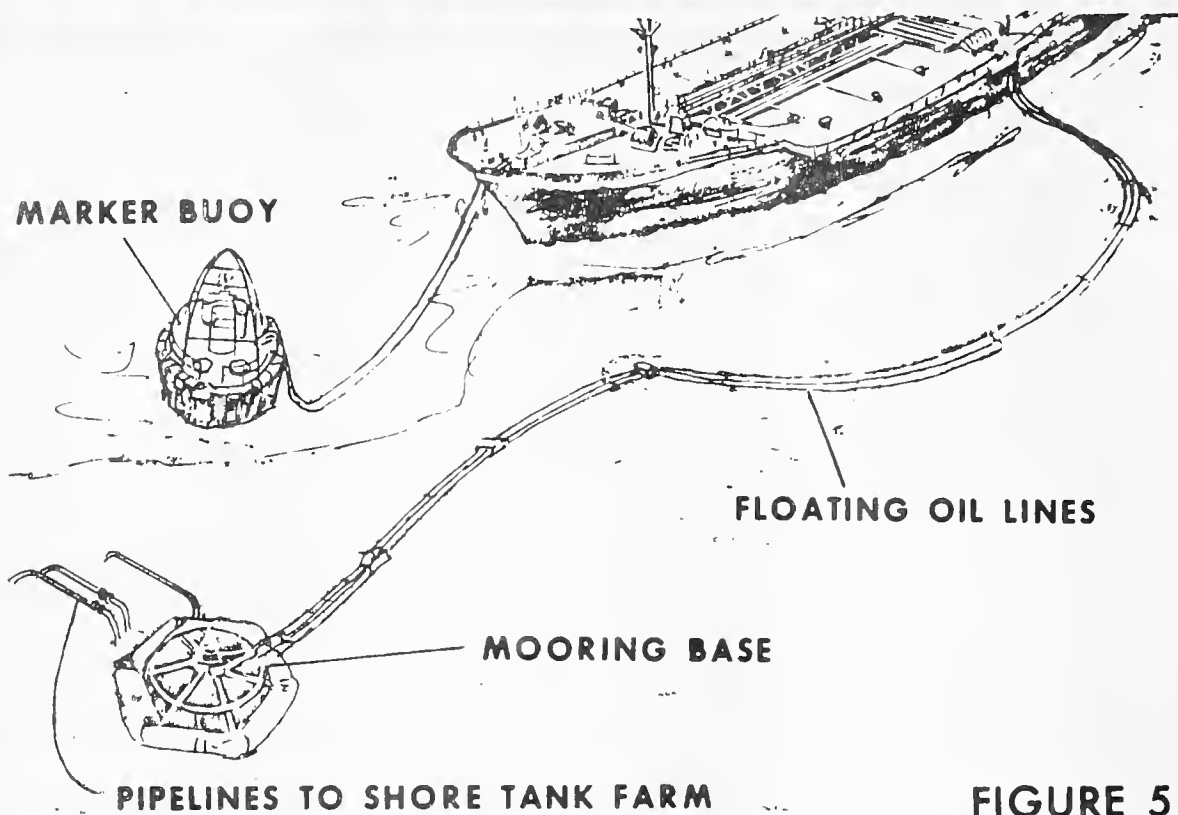


FIGURE 5

SINGLE ANCHOR LEG MOORING SYSTEM

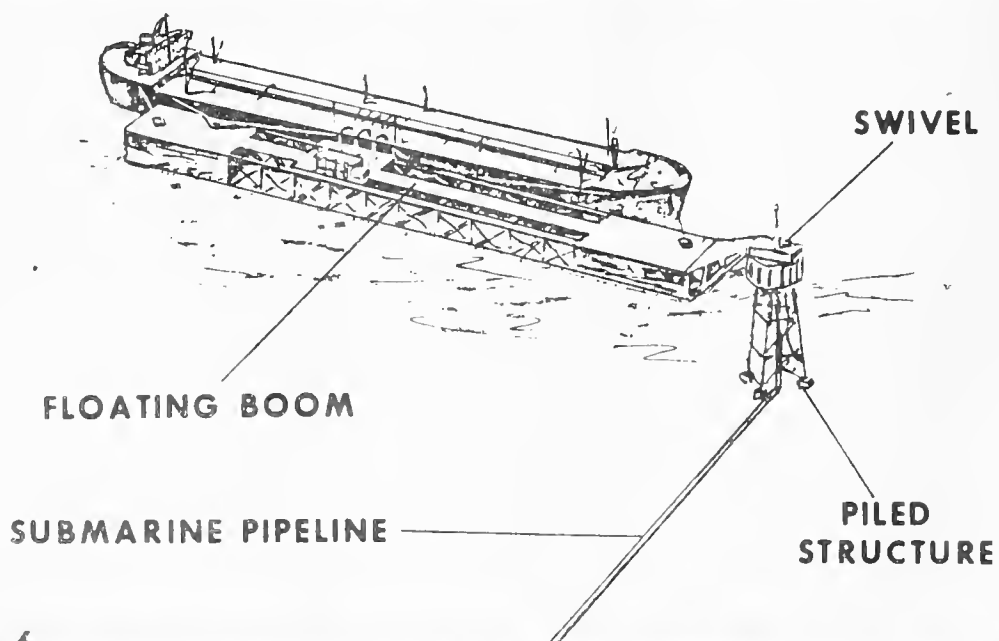


FIGURE 6

SINGLE POINT MOORING PIER

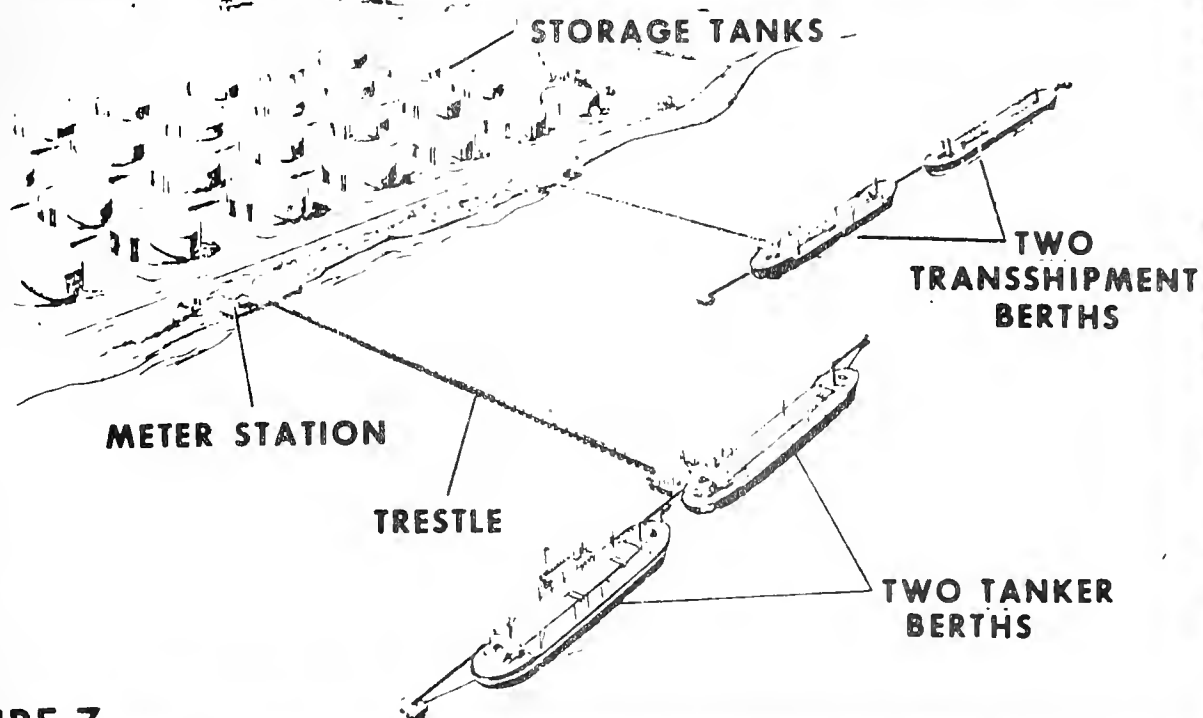


FIGURE 7

MARGINAL PIERS

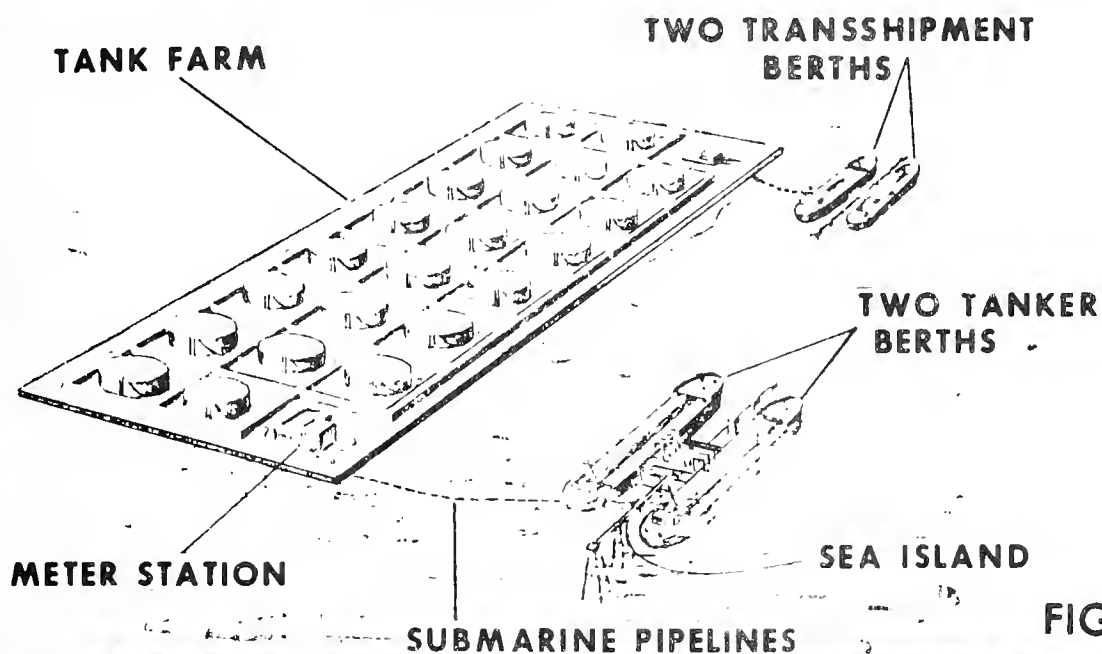


FIGURE 8

ARTIFICIAL ISLAND WITH SEA ISLAND BERTH

onshore storage areas. Because the sea island is fixed and free on both sides, ships may dock at both sides of the island concurrently. As with the marginal pier, the length of the sea island determines the number of vessels at berth.

Artificial Islands - Artificial islands (Figure 8) are the most expensive type of deepwater port facility; however, they have unlimited potential. Such islands are most likely to be constructed of material hydraulically pumped from the ocean floor into a rock dike forming the perimeter of the island. The perimeter is protected with heavy armor stone or precast concrete units, which provide protection under severe sea conditions. The size of the island is dependent upon its use. It is serviced by either a bulkhead docking facility or by one of the other mooring systems previously discussed. In addition to providing petroleum discharge, storage and transfer facilities, the island can be used to serve the needs of other industries such as waste processing, electric power generation, petrochemical plant oil refineries and offshore airfields. A study of the operating characteristics of the offshore complex is necessary to determine the choices of design, layout and construction. Other functional and operating requirements affect the design decisions concerning the offshore berth, the supporting pipeline and the shore facility

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